POWER

Volume 60 New York, July 1, 1924 *No.* 1

Independence Day

IT IS almost a century and a half since this country embarked upon the great adventure of a nation ruled by its citizenry.

Notwithstanding universal suffrage there is a legitimate question as to how much the man on the street has to do with the Government, how much he cares for his sovereignty and how dependent the nation, as now conducted, is upon his opinion and participation.

A couple of centuries is a short period in the lifetime of a nation, and our success, with a continent of undeveloped resources to draw upon, should not make us too confident and cocky.

While the statesmen and politicians have been busy getting and staying elected and grinding grists of laws, the engineers have been doing the things that have made it possible to conquer the wilderness and live upon the modern plane.

Watt's engine was new when the Declaration of Independence was signed. It was not applied to spinning until 1785 and to weaving until well into the last century.

The steam engine has made the railroad and steam navigation possible, and the later invention of the internal-combustion engine has given us the automobile and the aeroplane.

The development of textile, shoemaking, wood-and metal-working, agricultural and other sorts of machinery, with the steam engine to drive them have made our factory and industrial system possible and multiplied the productive capacity of our man power.

Against the crude waterwheels of colonial times we have units of 70,000 horsepower each, with efficiencies of 94 per cent.

In place of the mounted courier we have instant communication by the telegraph, the telephone and the radio.

Electricity, only a mysterious natural phenomenon at that time, has become one of our most useful servants, lighting our homes, offices, workshops and streets, bringing power in small or large quantities to the point of application and making available where it can be usefully applied the wasting energy of inaccessible waterfalls.

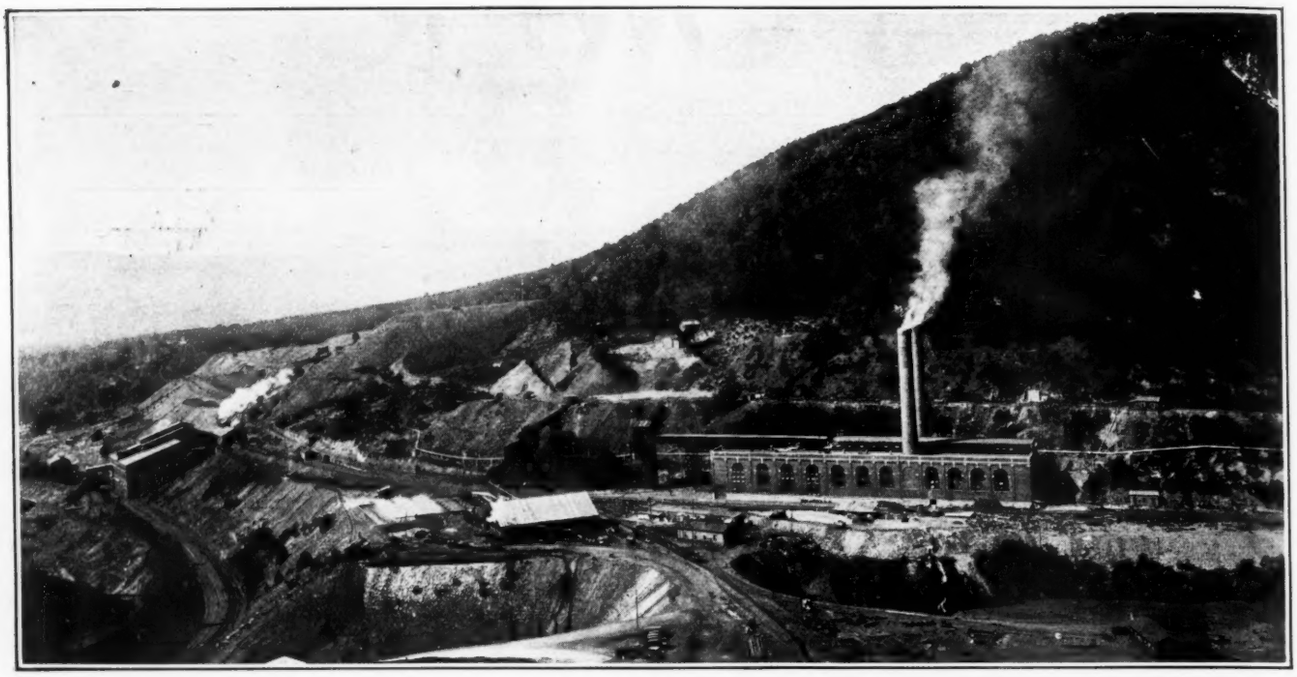
Modern steel construction became possible only in the latter half of the last century. The first structural iron beam was not rolled until 1855.

The chemical and metallurgical engineer has furnished us with materials undreamed of by our fathers.

This period has seen the development of photography, refrigeration, the phonograph, the movie, the steam turbine, the gas and oil engine, the mechanical stoker, conveying machinery, the elevator, illuminating gas, pulverized coal, the typewriter, the sewing machine, the power printing press, the hundreds of contributions of the inventor and the engineer which make the work of the world easier and life for the common citizen more worth the living.

These are the things that make a nation great, but the names of the men who did them will not figure in the Fourth of July oratory.

F. R. Low



Pulverized Anthracite Slush Burned at Lykens

THE successful application of pulverized coal in the firing of stationary boilers and the ability to burn in pulverized form practically any and all grades of coal with an approximately equal degree of thermal efficiency, have brought about the recent utilization of coal that heretofore had practically no market value.

Constituting a large percentage of this class of coal is the small-sized anthracite (smaller than No. 3 buckwheat) which up to a recent date was considered waste incident to anthracite mining and averages approximately 8 per cent of the coal mined.

The accumulation of this fine coal has been going on many years until mountains of this material are piled around the collieries. The beds of the rivers and creeks are also solid with the material. The total amount, probably running to nearly one hundred million tons has formed in the mining regions.

As all fine anthracite is referred to generally as culm, it might be well before going farther to point out the difference between culm and slush. A culm bank, as it is known in the mining region, contains all waste products from a colliery and consists of, depending upon its age, any coal that was rejected as unmarketable at the time, with slate, rock, breaker refuse and in the majority of cases ashes from the boiler plant. A slush bank consists entirely of coal free from any rock or slate, but so fine as to be unmarketable; the fine reject from breaker or washery; a mixture of water and coal; all passing the smallest coal screens, sometimes called sludge and silt. Slush is being made at the present time from all breakers and washeries that are re-treating culm banks.

ONE of the first power plants to utilize anthracite slush in pulverized form. Coal mixed with 75 per cent water pumped 2,500 ft. under 400 ft. head and dewatered at plant. Boiler plant contains six 5,000 and six 6,000-sq.ft. water-tube boilers. Present generating capacity 6,400 kw. Preparation plant in separate building. Drag scraper and screw conveyors employed in coal handling.

The new power plant of the Susquehanna Collieries Co. erected in 1920 and 1921 to supply current to its Short Mountain and Williamstown collieries, was the second commercial installation to use anthracite slush in powdered form, the first and smaller installation having been built by the same company at its Lytle colliery in 1918.

At the time this plant was put into operation, the steam for operating the Short Mountain colliery was being supplied by three boiler plants with a total of nine water-tube boilers of 5,000 sq.ft. of heating surface and three locomotive-type boilers of 1,000 sq.ft. of heating surface. At the Williamstown colliery five boiler plants were in operation, containing a total of fourteen water-tube boilers of 5,000 sq.ft. of heating surface and three locomotive-type boilers of 750 sq.ft. of heating surface. The combined operating forces of these eight plants, including firemen, water tenders, ash men, coal passers, boiler cleaners, etc., totaled 154 men, and the coal consumption for the year 1917 amounted to 203,631 tons, the average boiler efficiency in these plants being around 35 to 40 per cent. The fuel burned was all commercial coal, about 90 per cent of which was No. 3 buckwheat and the remainder No. 2.

During the latter part of 1917 an exhaustive study was made as to a means of reducing the power cost at the several collieries of the com-

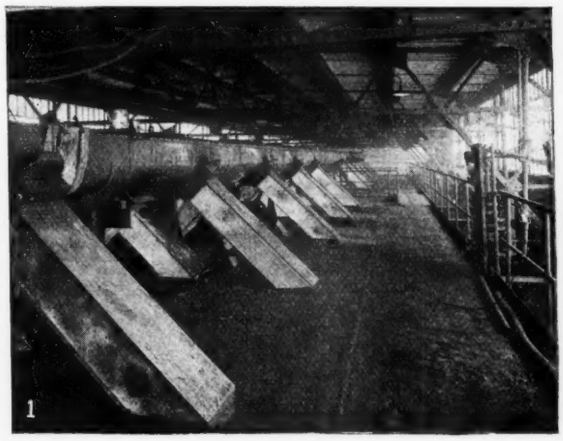


Fig. 1 — View of screw conveyors over pulverized-fuel hoppers

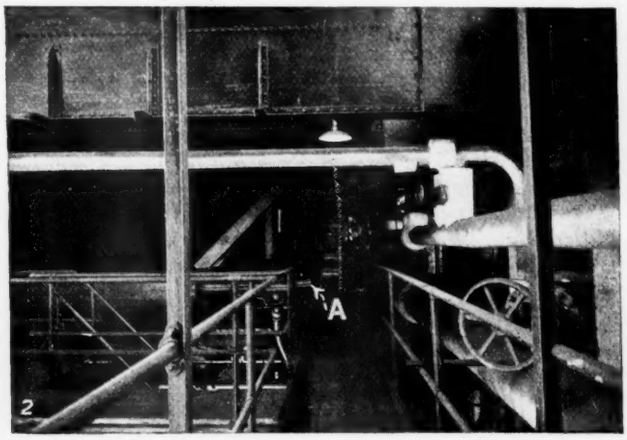
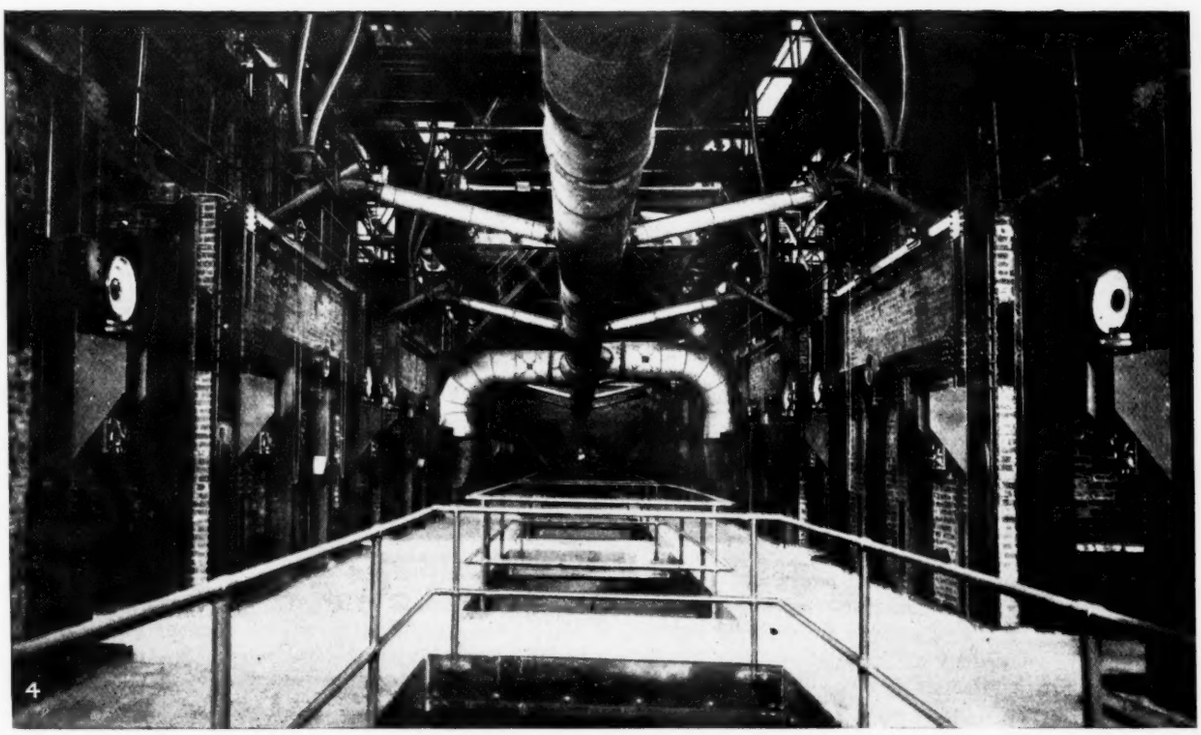


Fig. 2—Coal bunkers and screw feeders above operating aisle

Fig. 3 — One unit of the dewatering and coal-stacking equipment

Fig. 4—Central boiler operating aisle; six boilers on each side



pany, and this led to an investigation into the possibilities of burning anthracite slush in pulverized form in the new power plants which constituted part of the program of rehabilitation.

At this time the problem was discussed with the Fuller Engineering Co. and the mining company made an appropriation for an experimental plant consisting of a 2,500-sq.ft. B. & W. boiler, a 42-in. screen-type pulverizing mill and a rotary drier that the mining company had on hand. This research work was continued from the latter part of 1918 to the end of 1920 under the supervision of R. M. Walker, consulting engineer of the mining company with C. W. Lotz combustion engineer in direct charge of the work, and it might be stated that the ultimate success of burning pulverized anthracite is largely due to his work.

For this experimental work the combustion chamber

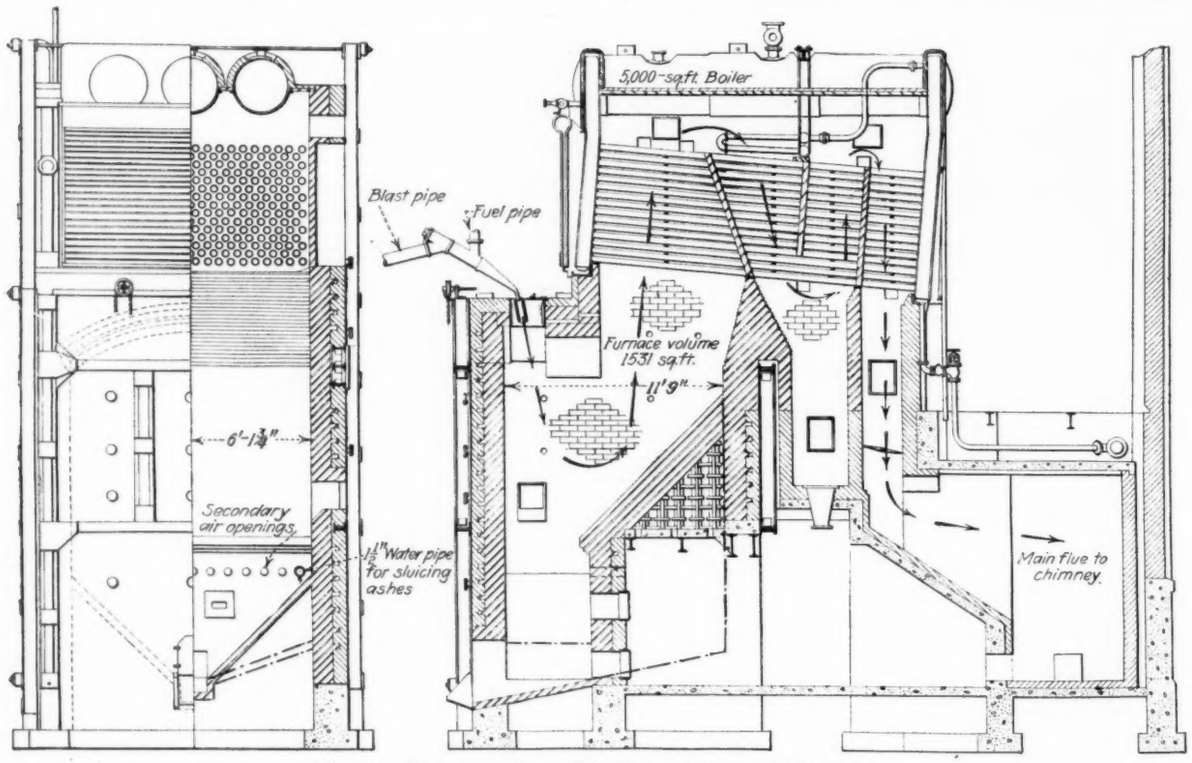


Fig. 5—Cross-section of boiler setting and furnace

Dot-and-dash line indicates change recently made in combustion chamber, 45-deg. slagging shelf being entirely removed.

was extended out in front of the boiler about 32 in., was made the full width of the boiler and about 9 ft. deep, with approximately 13 ft. between the boiler headers and the combustion-chamber floor.

The first trial was made with a round-type burner located in the furnace front about six feet from the bottom. As this resulted in heavy slagging and destruction of the ignition arch and brickwork of the rear wall, further experiments were made with several types of improvised burners located at different elevations in the furnace front, the final trial being conducted with a long, narrow burner constructed of sheet iron and placed in the top of the combustion-chamber extension. The secondary air in all cases was introduced through openings in the rear wall directly above the furnace bottom. These experiments showed that low-volatile fuels could be burned only in suspension by preheating the fuel to ignition temperature after leaving the burner in the furnace proper, and also demonstrated the importance of introducing the coal into the furnace in the form of a narrow curtain, which method, it might be recalled, has since become more or less standard practice.

With these preliminary studies completed and the possibilities of a material saving in power costs assured, it was decided to adopt this method of firing in the new plants for which plans were already under way.

The slush, with a consistency of about 25 per cent coal and 75 per cent water, is pumped from the breaker and washery a distance of approximately 2,500 ft. and against a head of 400 ft., to a point on the side of the mountain adjacent to the power plant. It may appear that considerable power is expended in pumping three pounds of water to each pound of coal over this distance, but since the slush leaves the breakery and washery with waste water, it was considered more economical to pump the water and slush to the plant and then dewater than to convey the solid coal the same distance.

At the plant the coal is first discharged into two dewatering devices consisting of two concrete tanks and four slow-moving drag scrapers. The latter remove the coal from the tanks and discharge it directly to two coal stackers, one of which is shown in Fig. 3.

The stackers, each of which consists of a 90-ft. boom carrying a drag scraper, were developed in the consulting engineering department by E. B. Worthington, mechanical engineer, and provide a practical and economical means of storing coal.

The lower side of the trough in which the scraper carries the coal is fitted with a number of sliding gates, permitting the coal to be discharged at any point along the boom. The boom is arranged to swing through an angle of 180 deg., and this provides facilities for stacking approximately 100,000 tons with the two units in operation. The general arrangement of the dewatering

and stacking and reclaiming equipment is shown diagrammatically in Fig. 9. Upon leaving the stacker the coal contains about 30 per cent moisture, but after standing in the pile for about 48 hours the moisture has decreased to around 10 per cent.

The reclaiming of the coal from the storage pile is accomplished by a scraper bucket operated from a motor-driven drum hoist, suitable anchor posts being arranged around the pile. The drum hoist is mounted on a turntable with a central discharge, and this feature permits swinging the drum in line to suit any position

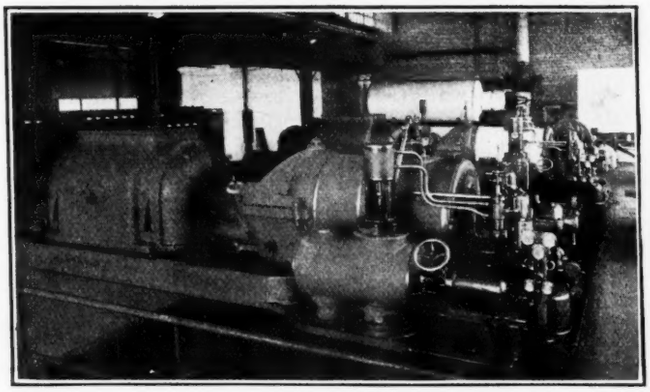


Fig. 6—View of turbine room showing two 3,200-kw. units

in which the scraper may be required to operate, the entire operation of dewatering, stacking and reclaiming the coal requiring the services of only two men.

From the discharge hopper of the drag scraper the coal is conveyed by a scraper-type conveyor to a distributing conveyor above the raw-coal bunkers in the pulverizing house. From the bunkers it is passed to two 25-ton per hour double-shell driers, hand-fired. Passing through the driers, the moisture in the coal is reduced to about one per cent.

The coal as discharged from the driers is elevated into a concrete dry-coal bin located over the pulverizing room and arranged with suitable discharges to eight 42-in. screen mills, four of which are belt driven from vertical motors and four geared-type direct connected to horizontal motors.

The screen test of the slush as fed to the mills runs about 70 per cent through a ¾-in. screen, and the finished material leaving the mill runs about 82 per cent through a 200-mesh. It may be recalled that this is a much finer product than is generally considered necessary with bituminous coal. This fine grinding, however, appears necessary with anthracite slush in order to obtain proper ignition owing to the low volatile content of 8 per cent as compared with bituminous coals having 30 to 40 per cent volatile.

The mills discharge the pulverized coal into screw conveyors, which in turn feed into duplicate systems of bucket elevators which carry the coal to a point above the boiler bunker level from where it is conveyed by duplicate screw conveyors to the fuel bins above the boiler aisle. As each conveyor is fitted with discharge chutes to each fuel bin, as shown in Fig. 1, one conveyor only is operated at a time, thus leaving one as a spare. The total capacity of the pulverized-fuel bins is approximately 250 tons, or a supply sufficient for a 24-hour full load of the station.

Referring to Fig. 4, the boilers are arranged in two rows, with six boilers on each side of the operating aisle. There are six 5,000-sq.ft. horizontal water-tube boilers equipped with superheaters and operated at 190 lb. pressure, and six 6,000-sq.ft. boilers of the same type without superheaters operating at 145 lb., all the boilers being designed for 200 lb. working pressure. The normal pressure of 195 lb. carried on six of the boilers was selected to suit the main generating units, while the pressure of 145 lb. carried on the remaining boilers was governed by the local colliery, in which there are two 48x72-in. hoisting engines and two 3,000-cu.ft. steam-driven air compressors and underground pumps. Provision has been made, however, for operating any of the boilers on either service by making the steam header in the form of two connected loops with sectionalizing valves between each boiler.

A cross-section of the furnace and boiler setting is shown in Fig. 5. The combustion chamber is extended out in front of the boiler sufficient for a good burner setting. It will be seen that the design of the combustion chambers is a departure from the usual practice. The floor of the chamber slopes at an angle of 45 deg. from the bridge wall to within 4 ft. of the front wall, the narrow portion at the front of the chamber serving as an ashpit. On the 5,000-sq.ft. boilers the furnace volume is 1,531 cu.ft., giving a ratio of square feet of heating surface per cubic foot of furnace volume of 3.26. On the 6,000-sq.ft. boilers this ratio is 3.76.

The ashes are removed from the pit by sluicing, the discharge from the mine pumps being used for this service. The bottom of the pit slopes from the side walls into a trough at the center. Water is led into the furnace at each side wall and flows down the inclined floor, carrying the ash with it. From the central trough

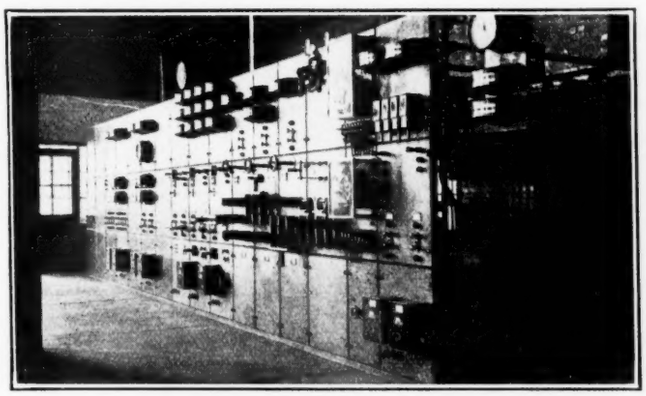


Fig. 7—Main switchboard on turbine-room floor

the ash is washed out through a swinging door to a common duct below the central aisle and discharged into a suitable space outside the building. The sloping floor of the ashpit is grooved in order to reduce the water surface exposed to the radiant heat of the furnace. The heavy dot-and-dash line shown in the section Fig. 5 indicates the change recently made in the combustion chamber of one of the boilers, but at the time of writing no tests have been conducted to determine what improvement has been made in the efficiency of the boiler.

Each boiler is fired by one burner located in the arch forming the top of the combustion-chamber extension.

The opening in each burner is approximately 2½ in. wide by 5 ft. 2 in. in length. Each burner discharges directly against a hinged deflector (see Fig. 8), the position of which is controlled by a chain wheel and

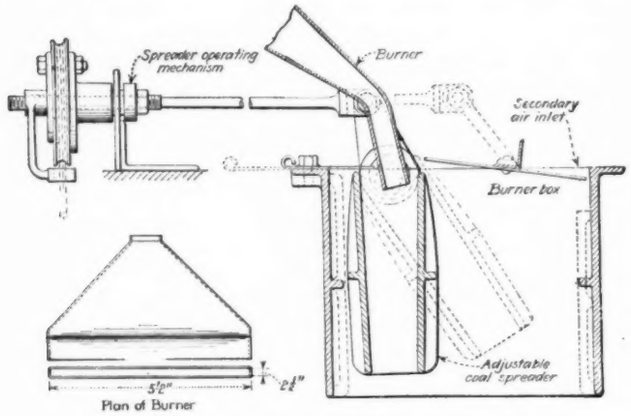


Fig. 8—Plan and section of pulverized-coal burner and spreader

screw operated from the floor. In this way the flame travel can be adjusted to suit the load condition. Provision is also made in the cast-iron housing surrounding the burner for admitting secondary air, a damper being fitted to the top of the housing and operated from the floor.

The feeders, two for each burner, are mounted directly below the pulverized-fuel bins with the controls conveniently located on the boiler fronts. The primary air is supplied by two motor-driven fans located between No. 3 and No. 4 boilers of each row and discharging midway into the primary air header, which is carried along the length of the boiler room directly above the operating aisle.

Each row of six boilers has a single stack with two breechings, the former in the center with three boilers on each side. The stacks are radial brick 12 ft. in diameter at the top and rise 175 ft. above the base.

The present installed turbo-generator capacity is 6,400 kw. in two units of 3,200 kw. each, provision being made in the station layout for an additional unit of 7,500 kw. The condensers are of the jet type and are mounted directly below the turbine exhaust, a spray pond being used for cooling the injection water.

The feed water to the boilers is supplied by three centrifugal pumps, two of which are motor-driven and one steam-driven. The pumps are in the turbine-room basement directly below the feed-water heater. Exhaust steam for heating the feed water is supplied by the removal pump of each condenser and the discharge of the rado-jet air pumps. The exhaust of the two 3,000-cu.ft. air compressors at the colliery is also returned

DATA ON PRINCIPAL EQUIPMENT IN LYKENS POWER PLANT SUSQUEHANNA COLLIERIES CO.

GENERAL

Location of plant	Short Mountain Colliery, at Lykens, Dauphin County, Pa.
Character of service	Steam and electric power to collieries
Capacity, present	Steam plant, 66,000 sq.ft. boiler-heating surface; electric plant 6,400 kw.
Capacity, ultimate	Steam plant, 82,000 sq.ft. boiler-heating surface; electric plant, 14,000 kw.

BOILERS, SUPERHEATERS AND AUXILIARIES

Manufacturer	Edge Moor Iron Co.	
Type of boiler	Horizontal drum, water-tube, four-pass.	
Number installed	12	
Water-Heating surface, per boiler	Six 5,116 sq.ft.; Six 5,932 sq.ft.	
Number of tubes per boiler	231	293
Size of tubes	4 in. dia. by 20 ft.	4 in. dia. by 18 ft.
Size of drums	35½ in. dia.	35½ in. dia.
Boiler pressure	200 lb.	200 lb.
Type of superheaters	Convection	
Manufacturer	Power Specialty Co.	
Working temperature at 100 per cent rated capacity	452 deg. F.	
Soot blowers	(Vulcan)	Vulcan Soot Cleaner Co.
Feed-water regulators	(Copes)	Northern Equipment Co.

FUEL

Kind	Pulverized anthracite slush
Heat value, B.t.u. per lb. as received	11,250

FURNACES

Firebrick	Evans Howard Fire Brick Co. Valentine Bros.

COAL-HANDLING EQUIPMENT

Complete conveying equipment	Link-Belt Co.
Storage	Steel bins

DRYING, PULVERIZING AND COMBUSTION EQUIPMENT

Driers	Two, double-shell type	Ruggles-Coles Eng. Co.
Pulverizers	Four 42-in. screen type, belt drive,	Fuller-Lehigh Co.
	Four 42-in. screen type, gear drive	Fuller-Lehigh Co.
Fans, primary air, two		Buffalo Forge Co.

STACKS

Type	Radial brick
Constructed by	Alphonse Custodis Co.
Height above base	175 ft.
Inside diameter at top	12 ft.
How supported	On foundation at grade level

FEED PUMPS AND AUXILIARIES

Manufacturer		Allis-Chalmers Mfg. Co.
Number	3	
Type and size	One 3-in. five-stage centrifugal Two 3-in. four-stage centrifugal	
Capacity, gal per min. each	400	
Drive	One pump, 100-hp. motor	Allis-Chalmers Mfg. Co.
	One pump 75-hp. motor	Allis-Chalmers Mfg. Co.
	One pump, 110 hp. turbine	Terry Steam Turbine Co

FEED-WATER HEATERS

Manufacturer	The Hoppes Mfg. Co.
Type	Horizontal open-type, with V-notch meter, recorder and integrator
Capacity	300,000 lb. per hr. at 210 deg. F.

MAIN GENERATING UNITS

Manufacturer		Allis-Chalmers Mfg. Co.
Type	Reaction	
Number installed	Two	
Rating kw. 80 per cent power factor, each	3,200	
Speed, r.p.m.	3,600	
Steam condition turbine throttle	175 lb., 450 deg. F.	
Vacuum	27 in.	
Type of generator	3-phase, 60-cycle, 2,300-volt	
Steam consumption, lb. per kw.-hr.	One-half load 18.1, three-quarters load 16.75, full load 16.1	

GENERATOR AIR COOLERS

Number	2	
Capacity, each	16,500 cu.ft. per min.	
Manufacturer	Spray Engineering Co.	
Drive, 7½-hp. motors		General Electric Co.

EXCITERS

Number	One 100-kw. turbine driven	Allis-Chalmers Mfg. Co.
	Two 100-kw. motor-driven	General Electric Co.

SPRAY-POND PUMPS

Manufacturer		Worthington Pump & Machinery Corp.
Number	2	
Type and size	12-in. centrifugal	
Speed r.p.m.	1,200	
Capacity, each, gal per min. at 45 ft. head	4,500	

MISCELLANEOUS EQUIPMENT

Switchboard		General Electric Co.
Piping		M. J. Daugherty Co.
Pipe covering		Johns-Manville Co.
Valves		Crane Co.
Steam-flow meters (1 indicating)		General Electric Co.
(1 recording and integrating)		Bailey Meter Co.
Recording pressure gages		Foxboro Co.
All motors (except as noted)		General Electric Co.

to the plant, and any excess is discharged to the atmosphere.

The preparation plant is operated during the sixteen hours off-peak period that the collieries are idle. During this time sufficient coal is prepared for the twenty-four hour operating period of the station.

The cost of preparing and handling the coal at the Lykens plant averages about 60 cents a ton over a twelve-month period. This includes operating and maintenance, labor and supplies, including power and superintendence, but not investment charges. The cost of pulverizing alone is about 24 cents a ton.

The cost of preparing and handling the coal here given may at first appear high, but when it is remembered that the plant is being operated considerably below capacity, and that the cost of pulverizing and the maintenance charges on the mills increases rapidly with the degree of fineness of pulverization and the percentage of ash (the coal in this case is pulverized to a

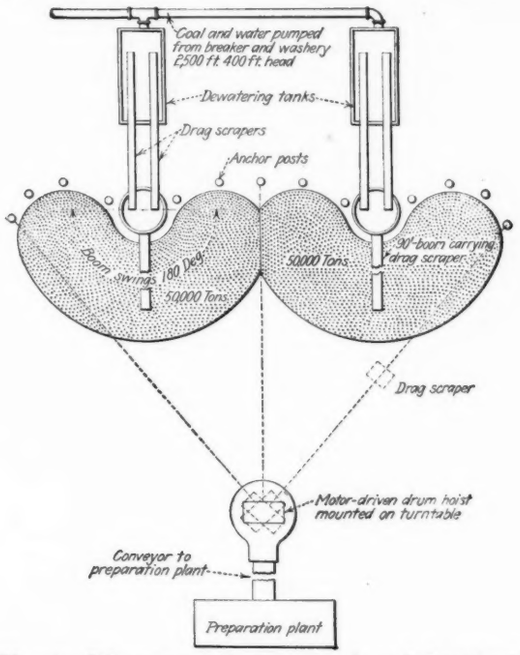


Fig. 9—Diagrammatic layout of coal dewatering and stacking equipment

fineness of 82 per cent through a 200-mesh screen and contains 20 per cent ash) and that the pulverized coal is conveyed a distance of 500 ft. from the preparation plant to the bunkers about the boilers, this cost is not excessive.

The plant was designed and constructed under the direct supervision of R. S. Walker, consulting engineer of the M. A. Hanna Co. of Cleveland, which operates the Susquehanna Collieries Co., and his associates, A. J. Cayia, his assistant, E. B. Worthington, mechanical engineer, C. H. Matthews, electrical engineer, and C. W. Lotz, combustion engineer. Co-operating with these were H. L. Reese, electrical engineer, and W. E. Weineck, construction engineer, of the office of R. A. Quin, manager of the Susquehanna Collieries Co. at Wilkes-Barre, Pa., and E. A. Van Horn, superintendent of the Lykens Division of the same company. The plant is operated under the direction of H. B. Jones, chief station engineer.

All construction work was carried out by the H. C. Felver Co., of Cleveland, Ohio.

Notes on Semi-Diesel Lubrication

By G. Grow

A vital factor in the operation of an oil engine regardless of its class is the design of the lubrication system and the system of cleaning the used oil so that it may be put into the system a second time. In fact, in certain types of oil engines the cost of the lubricating oil used per day often exceeds the cost of the fuel burned, for it should be understood that the amount of lubricant consumed depends on the rated capacity of the engine and not on the load carried. As example, a 100-hp. semi-Diesel engine may run four hours on a gallon of lubricating oil and the amount would not differ whether the load be 100 hp. or but 25. The same reasoning applies to the Diesel although the number of horsepower-hours delivered by the Diesel per gallon of lubricating oil may range from 2,000 to 4,000. This difference is traced to the higher average cylinder temperature of the hot-bulb engine and its high piston temperature. A two-cycle hot-bulb engine will have a mean cylinder temperature above 700 deg., and the piston head will be practically red hot at its center. This means that the cylinder must be copiously oiled or it will become overheated.

The lubricating oil is generally introduced through three lines to the cylinder walls. One of these lines is, in vertical engines, below the air transfer port; a second one is in line with the crankshaft so that its piston pin, which has a scraper at one end, can scoop up the oil as it issues from the port. The third oil line enters below the exhaust ports.

The location of the last oiling pipe is bad, for the rush of gases blowing out the cylinder ports carries a good deal of the oil with it and accounts for much of the heavy consumption. One manufacturer decided that this oil line could be shifted away from the piston, and found that the consumption was lowered by over 50 per cent.

Since the longer the oil remains in the crankcase the greater is its evaporation, it is readily seen that, if given time, the entire amount will either be vaporized or picked up by the air in the shape of a spray and be put back into the cylinder when the transfer port opens. Usually, most of it finally blows out the exhaust ports with the scavenging air but much of it burns along with the fuel, and this action partly explains the remarkable results at times obtainable from the hot-bulb engine in the shape of fuel consumption—the engine actually being run on lubricating oil as well as fuel oil. All recognize the advantage in the way of freedom from cylinder carbonization secured by removing this oil. Many engines, however, are merely fitted with a check drip valve; the oil dripping out and being caught in a bucket, is thrown away, since it is black in color and is rather dirty.

An engine builder has gone a step farther and has incorporated a small oil filter in the design of the engine. The cleaning apparatus consists of a small cast-iron tank into which the oil drips, a pump, driven off the mechanical lubrication rod, which lifts the oil from the sump into the filter, which is placed close to the hot exhaust pipe. The filter has bags of cloth to remove the dirt, etc. Being close to the exhaust, the oil is kept hot so that the fine dirt will settle easier. The oil after clearing is returned to the mechanical lubricator. This filtering has increased the horsepower-hours per gallon of lubricating oil by 75 per cent.

Is the Parsons Line Straight or Curved?

BY CARROLL F. MERRIAM

Some time ago, as reported in the April issue of "Power," the British Journal, "The Engineer," questioned the accuracy of the economy results obtained at Lakeside, on the basis that a straight Parsons[1] line plotted through a few test points and extended to the axes, showed some evaporation with no fuel consumption. The present writer shows the fallacy of assuming that the Parsons line is necessarily straight.

IN THE April 1 issue discussion was invited on the question of why the Parsons line of a certain station should not pass above the origin. Falling below as it does leads to the absurd conclusion that below one particular load water can be evaporated without burning any coal. Assuming that weights of water and coal are beyond question, we must look further into the nature of the Parsons line to find a possible explanation.

Suppose that all losses in a steam boiler were constant regardless of the load. The Parsons line would then be made up of the sum of two quantities as shown in the upper diagram of Fig. 1. From this an efficiency versus load curve can be constructed.

The graphical construction for plotting the efficiency curve is indicated. Any point on the line *OB* represents one hundred per cent efficiency, since *OB* represents the heat actually turned into steam. The construction shown is such that (by similar triangles) *AC* is to *AB* as the water actually evaporated for the given fuel consumption is to the water that would have been evaporated if there had been no losses. By laying out the vertical scale of the lower diagram so that *AB* represents 100 per cent, *AC* becomes the corresponding efficiency.

Efficiency Increasing Steadily with Load

For the assumed conditions Fig. 1 shows that the efficiency approaches 100 per cent as a limit regardless of how much the boiler is forced, and that there is no point of maximum efficiency. Although experience tells us that this conclusion is contrary to fact, nevertheless the assumption is true to the extent that radiation losses, etc., especially with internally fired boilers, are about the same whether the fires are banked or running. It is this fact that at low loads gives the characteristic shape to efficiency curves in general.

The Parsons line for the case just considered is straight and passes above the origin. We now consider that, in addition to the fixed losses, there are those which are roughly proportional to the load. As long as the percentage of excess air and the flue-gas temperature remain the same, the heat carried away by the dry chimney gases would fulfill this condition. In this case the Parsons line would be made up of three quantities as shown in the upper diagram of Fig. 2. The corresponding efficiency curve indicates that the efficiency approaches some definite value less than 100 per cent, but that there is no maximum. Although this is still contrary to our knowledge, nevertheless th

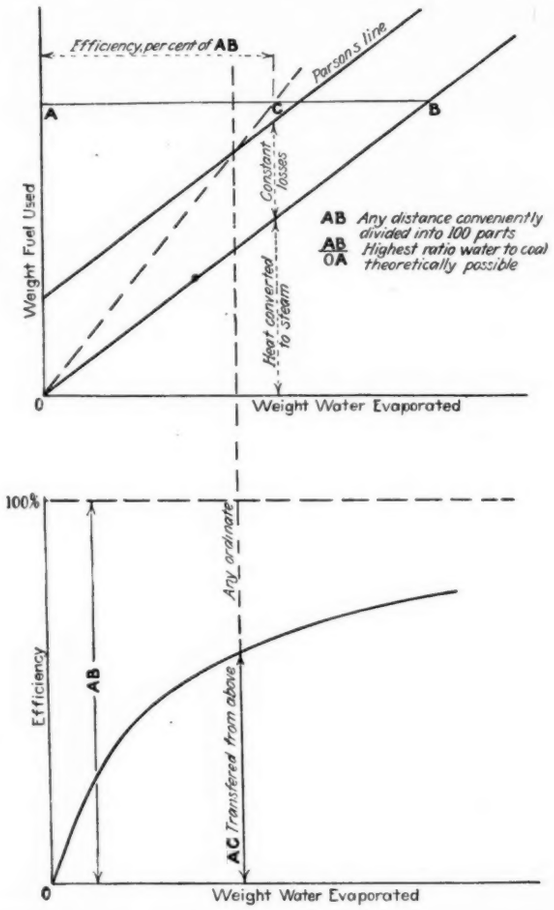


Fig. 1—With only constant losses, Parsons line is straight and efficiency continuously approaches 100 per cent

form of the curve comes distinctly closer to actual practice than that of Fig. 1, and would certainly be acceptable as a fair approximation. In this case, again, the Parsons line is straight and passes above the origin.

To approach the facts still closer, we must consider that practically all losses in a boiler are increased in magnitude somewhat faster than directly proportional to the load. When forcing, the higher stack temperatures cause the stack losses to increase faster than assumed in the previous example. The Parsons line with corresponding efficiency is shown in Fig. 3. In this case the efficiency actually does reach a maximum and begins to drop off with overload, and the Parsons

[1]The Parsons line corresponds to the Willans line of a steam engine and is ordinarily obtained by plotting the station fuel consumption for any period against the corresponding output of steam or kilowatt-hours. In British practice it is generally assumed that this line is necessarily straight so that the whole line can be determined from three or four points.—Editor.

line is no longer straight. It should be noted that tangents drawn to the curve below the point *E* of best efficiency pass above the origin. In like manner those above *E* pass below the origin, whereas a tangent to the curve from the origin will touch it at *E*.

The theoretical efficiency curves for a station having, for example, ten boilers are shown in the upper diagram

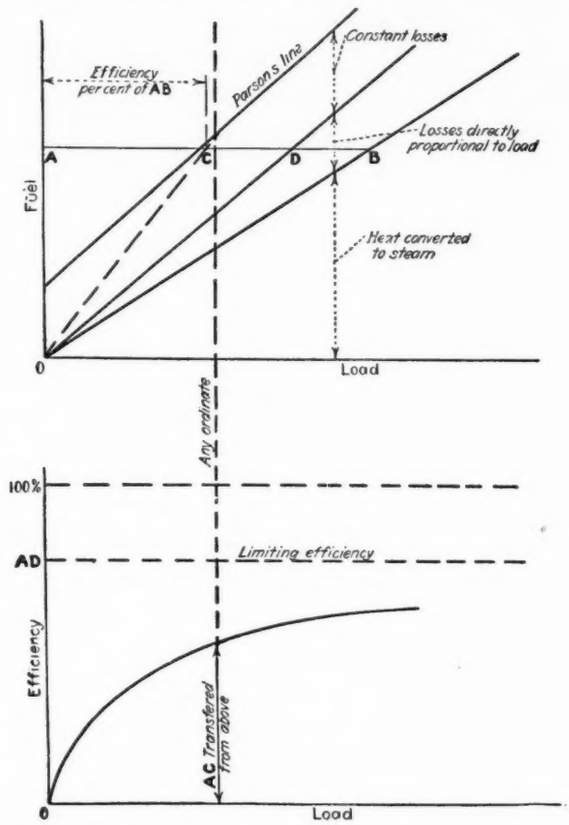


Fig. 2—When some losses are constant and some proportional to the load, Parsons line is straight and efficiency continuously approaches a limit less than 100 per cent

of Fig. 4. If all the boilers, similar and equally loaded, were used all the time, the curve for the station would be exactly like that for a single boiler, and is drawn in solid line. If, on the other hand, boilers could be cut in as needed without the necessity of holding some boilers banked in reserve, the curve would be the wavy dotted line.

In Practice Parsons Line Curves at Heavy Loads

In practice, however, the banking of boilers in reserve introduces stand-by losses, and so the actual curve would fall somewhere between the solid and the dotted. The effect of unequal loading would be to smooth the waves out of the curve and to reduce the values somewhat, especially at the higher rates of evaporation. This causes more or less of a general displacement to the left. The dot-and-dash line then represents the relation that might be expected in an actual boiler plant.

The lower diagram of Fig. 4 is constructed as indicated to show the Parsons line, assuming that the foregoing is correct. It will be noted that below the point *E* of maximum efficiency, there is a portion practically straight, which if extended will cut the axis at a point above the origin. However, above this section there is a portion through which an "average" line will strike the fuel line *below* the origin, as in the case cited.

We may conclude from this that, provided the instruments are known to be correct, it is probable that at least some if not all of the boilers in the plant are being forced beyond the point where they develop the greatest efficiency.

Parsons Line Has Many Uses

That the Parsons line is a measure of efficiency will be more readily appreciated when it is converted into an efficiency curve by the construction that is indicated in Fig. 1.

If the maximum number of pounds of water theoretically possible to evaporate per pound of fuel is not known, it is impossible to express the percentage of efficiency directly. However, the economy in number

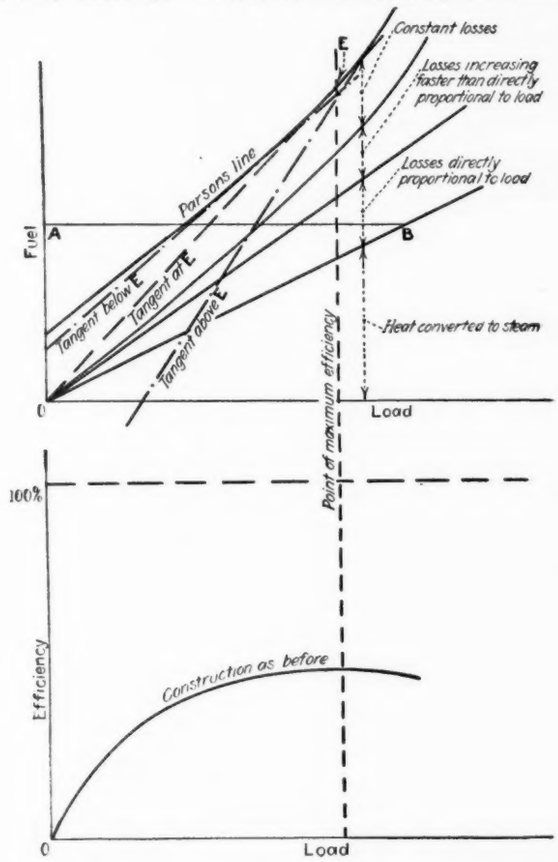


Fig. 3—Where certain losses increase faster than the load, Parsons line curves up and the efficiency curve has a maximum point

of pounds of water evaporated per pound of coal can easily be figured.

The Parsons line may also be constructed on the basis of any of the five following ratios, which express the relation between the amount of fuel burned and the weight of water evaporated: Pounds of coal as fired against pounds of water fed; pounds of dry coal against pounds of water fed; pounds of coal as fired against equivalent evaporation from and at 212; pounds of dry coal against equivalent evaporation from and at 212; pounds of combustible against equivalent evaporation from and at 212.

Naturally, the relation requiring the most corrections to bring to standard conditions will give the smoothest and most satisfactory curve, but the general shape will be the same and, when sufficient points have been determined to eliminate accidental errors, the same conclusions can be drawn from all. To plot simply the coal weighings against the feed-water meter readings of course involves the least amount of calculation, and the results are valuable in keeping tabs on the station performance from day to day.

The Parsons line is even more useful than a record of the plant efficiency because the load carried is thus taken into consideration. Should a new point fall below the average line of the previous, it would show improved economy, and vice versa.

Another advantage of the Parsons line is that its final slope at maximum load is a measure of the cost of the last increment of output. If the cost of cutting in additional boilers or of installing new equipment is

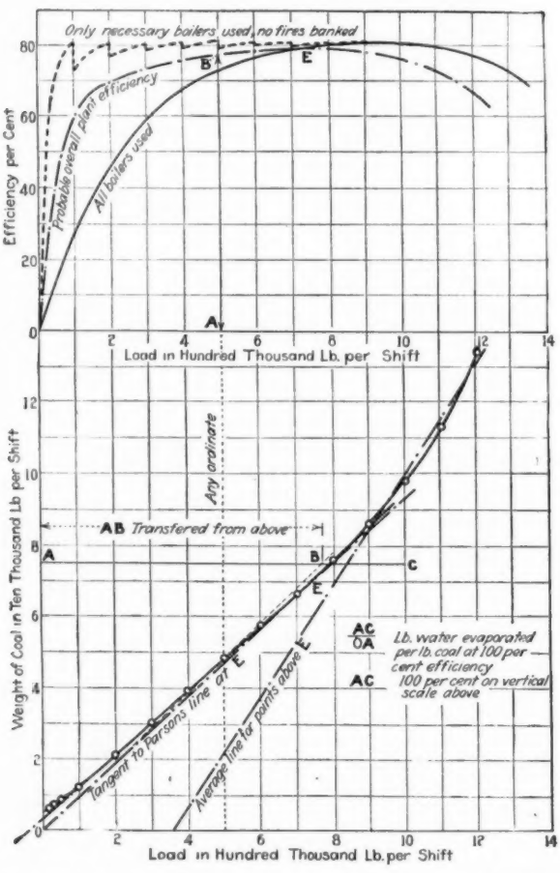

Only necessary boilers used, no fires banked
Probable overall plant efficiency
All boilers used
Efficiency per Cent
Load in Hundred Thousand Lb. per Shift
Weight of Coal in Ten Thousand Lb per Shift
Any ordinate
AB Transfered from above
Tangent to Parsons line at E
Average line for points above E
AC/OA Lb. water evaporated per lb. coal at 100 per cent efficiency
AC 100 per cent on vertical scale above
Load in Hundred Thousand Lb. per Shift

Fig. 4—Showing how it is possible for an "average" straight line through high-load tests to cut fuel line below origin

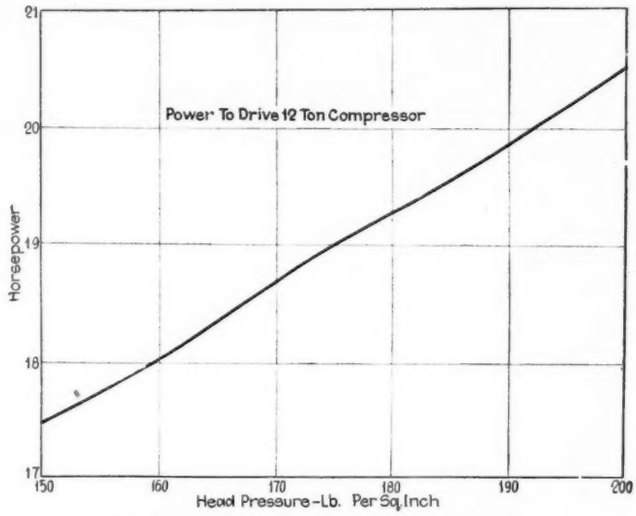
known, together with the number of hours heavy overloads may be expected to be carried, it can readily be determined whether it would pay to do either of these.

To return once more to the question of whether the Parsons line is straight or curved, it is clear that if it is straight the corresponding curve for efficiency or evaporation per pound of coal must continually approach a limiting value. If these curves have a maximum point the corresponding Parsons line cannot possibly be straight. Both theory and practice indicate the presence of such a maximum point.

High Condenser Increases the Power Consumption of Refrigeration Machines

BY A. W. FARRALL*

The economical operation of a compression refrigeration machine, from the power viewpoint, demands that the condenser pressure or, as commonly stated, the head pressure be kept as low as possible. In the illustration is shown a curve plotted from results of a test



Effect of head pressure on horsepower

on a 12-ton refrigeration machine. It will be seen that there is a gradual increase in the power consumption of the machine as the head pressure increases. With a head pressure of 150 lb. per sq. in. the machine required 17.5 hp., while with a head pressure of 200 lb., 20.5 hp. was required, or a saving of 3 hp. at the lower pressure. Assuming that the compressor was operated ten hours a day and that power cost two cents a kilowatt-hour, the total saving in the power bill per month of thirty days would be $13.42.

Knowing the effect of a high head pressure, it is desirable to consider the factors that influence this pressure. The temperature to which the ammonia is cooled is by far the most important. Ammonia coming from the compressor to the condenser is in vapor form, and in order for it to become liquefied in the condenser a certain amount of heat must be taken from it, the high pressure and cooling being the two factors that cause the liquefaction of the ammonia vapor. It is a property of ammonia vapor that the hotter it is the greater must be the pressure in order to cause it to liquefy. In other words, by increasing the pressure the boiling point and the condensing point are raised; by decreasing the temperature the condensing pressure is lowered. Therefore, in order to maintain a low pressure on the high side of the refrigeration machine, we must cool the ammonia down as much as possible.

In order to obtain the maximum cooling we must have a good supply of cold water—at least two gallons per minute per ton of refrigeration if the water is brought in at a temperature of 70 deg. F., and more water if it is warmer. We are all acquainted with the

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fact that shutting off the cooling water causes an immediate rise in the condenser pressure.

We must have plenty of condenser surface in order that the heat transfer may take place easily. Oftentimes the adding of more condenser capacity will pay for itself in a short time, because a lower condenser pressure will result.

The condenser should be kept free from scale and oil, for these two substances form a film that prevents the proper transfer of heat from the ammonia to the cooling water and thereby decreases the efficiency of the cooling system.

Hot Water Softener Saves Over $7,000 a Year

BY JAMES E. DURFEE*

An interesting example of the effect of water treatment is at the plant of the Buda Company, Harvey, Ill. Five water-tube boilers aggregating 14,000 sq.ft. of heating surface are installed, and they are operated usually at 200 per cent of rating. The steam generated is used for five 200-hp. steam hammers, three air compressors with a total capacity of 5,000 cu.ft. per min., and also for heating the plant, which has 160,000 sq.ft. of radiation.

Water conditions at Harvey are severe. The hardness of the Buda well water has gradually increased to 49 grains per gallon, while the Harvey city water contains 38.75 grains of incrusting solids per gallon. This water comes from artesian wells and is augmented from Chicago mains, which supply Lake Michigan water. The city water is variable in dissolved solids, as different amounts of Chicago water are used, depending upon the flow from the artesian wells. Analyses of these waters are given in Table I.

TABLE I—ANALYSES OF WATERS USED AT BUDA PLANT

	Buda Well Water	Harvey City Water	Lake Michigan Water
Calcium carbonate	12.60	12.40	4.80
Magnesium carbonate	.....	.....	1.51
Calcium sulphate	19.31	12.65	.....
Magnesium sulphate	15.72	12.91	0.94
Magnesium chloride	.....	.....	0.07
Silica	0.95	0.40	0.21
Iron and aluminum oxides	0.44	0.25	0.10
Suspended matter	0.32	0.14	0.03
Total incrusting solids	49.34	38.75	8.66
Sodium sulphate	.....	13.21	.....
Sodium chloride	.....	13.51	0.85
Total non-incrusting solids	35.95	26.72	0.85
Total solids	85.30	65.47	9.51
Hardness	39.90	32.46	7.45
Alkalinity	12.60	12.40	6.60

Previous to 1922 a home-made intermittent softener had been used, consisting of two 12,000-gal. tanks in which the water was mixed with the lime and soda ash for removing the hardness. This treating equipment operated on the batch principle, one tank being treated with chemical agitated by steam and then allowed to settle while the treated water from the other tank was being used. This treatment reduced the hardness to about 14 grains to the gallon, and in the feed-water heater the hardness was further reduced to 7 grains. Thus 60 per cent of the hardness was removed in the treating tanks, 20 per cent in the feed-water heater and 20 per cent remained in the water. The treatment did not eliminate scaling. So much hardness was removed in the feed-water heater that it had to be cleaned weekly, every six months scale about $\frac{1}{8}$ in. thick had to be removed from the boiler tubes by turbining, and it was necessary to flush the boilers every 10 days. The cost of the chemicals for treating the water was about $10 a day.

In 1922 the company installed a hot-process continuous-type water softener, with a capacity of 12,000 gal. an hour. The water enters at the top of the softener, where it is heated by exhaust steam to a temperature between 200 and 210 deg. F. After passing the heater the hot water is mixed with the chemicals, lime and soda ash, which are supplied automatically in proportion to the amount of raw water entering the softener, and the hot water mixed with the chemicals flows into the sedimentation tank, where chemical reaction takes place. The tank is large enough so that when the softener is operating at maximum capacity, the water remains in it for one hour, giving time for complete reaction and settling of the precipitated hardness. By the boiler-feed pumps the treated water is taken from the top of the sedimentation tank, at which point it is freed from suspended matter by a quartz filter, and with 2 to 2½ grains of hardness per gallon is delivered at a temperature of 200 to 210 deg. Notwithstanding the variation in the water test sheets show that the boiler feed is treated uniformly, without the necessity of carrying an excess of soda ash.

TABLE II—COST OF OPERATION AND SAVINGS EFFECTED BY HOT PROCESS SOFTENER

Depreciation, $6,500 ÷ 15 years' life		$433.33
Average interest at 6 per cent $= \frac{16}{15} \times \frac{\$6,500 \times 0.06}{2}$		208.00
Maintenance and repairs		350.00
Total annual fixed expense		$991.33
Fixed expense per day, $991.33 ÷ 365 days		$2.72
Chemicals, 169 lb. soda ash at $2.25 per cwt.	$3.80	
162 lb. lime at $1 per cwt.	1.62	
		5.42
Power, 42 kw.-hr. at 3c.		1.26
Labor		.50
Cost per day		$9.90
Cost per 1,000 gal. = $9.90 ÷ 99.4		$0.10
Savings Effected		
Saving in fuel—1,095 tons at $5.50		$6,022.50
Saving in boiler cleaning equivalent to 6 cleanings at $150		900.00
Saving in heater cleaning, $10 × 40 times per year		400.00
Annual saving from sources named		$7,322.50

In addition to the action of the lime and soda ash in removing the incrusting solids, heat removes a large part of the calcium carbonate hardness. Calcium carbonate precipitates out of the water while the other two products are gases. There is a daily saving of about $3.25 in lime due to the removal of the calcium carbonate hardness by the action of heat.

A recent analysis showed that a yearly saving of $7,322.50 was made by the softener, which is a return of over 110 per cent on the investment. This includes 1,095 tons of coal at $5.50 per ton, six boiler cleanings and 40 cleanings of the feed-water heater. The data are given in Table II, but do not include either the lubricating oil used by the engines, which is 35 per cent less owing to the fact that there are no impurities in the steam, or the reductions in replacement and repairs of pipe lines, valves, etc., which are not accurately calculable.

*Plant engineer, the Buda Co.

A method for conducting an oxidation test on lubricating oils has recently been developed at the United States Bureau of Standards. This consists in exposing a sample of the oil in a closed flask filled with oxygen to a temperature of 200 deg. C. for 2½ hr. The precipitate thrown out by a definite solution of the oxidized sample in petroleum ether is determined. The mass of this precipitate, expressed as a percentage of the original sample (10 g.), is taken as the oxidation value.

Oil Engines in Rock-Crushing Plants

IT IS one of the paradoxes of engineering that in those industries in which the cost of power is a large percentage of the total production costs, efficiency in the power house often receives but scant attention. For example, in rock-crushing plants the raw material costs but an insignificant sum, labor and power making up most of the expense of converting a cliff of rock into building material or railroad ballast. Labor has had its efficiency multiplied many times over by the introduction of the air hammer, loading mules, belt conveyors, etc. But how wasteful and antiquated are the engines and boilers in the power plant!

It is little wonder that for each horsepower delivered to the crusher lineshafting, from 10 to 20 lb. of coal is required. With coal costing five dollars and upward per ton, the excessive cost of operation has compelled the closing of many otherwise profitable plants, and new plants going in are being equipped with units of efficiencies comparable to those obtained in central stations.

The Southern Pacific Company, when designing two rock-crusher plants at Lucien, Utah, and Palisade, Nev., made a close investigation of the several types of prime movers and finally settled on the purchase of semi-Diesel oil engines as being the most efficient for the given conditions of operating hours, fuel costs and initial investment.

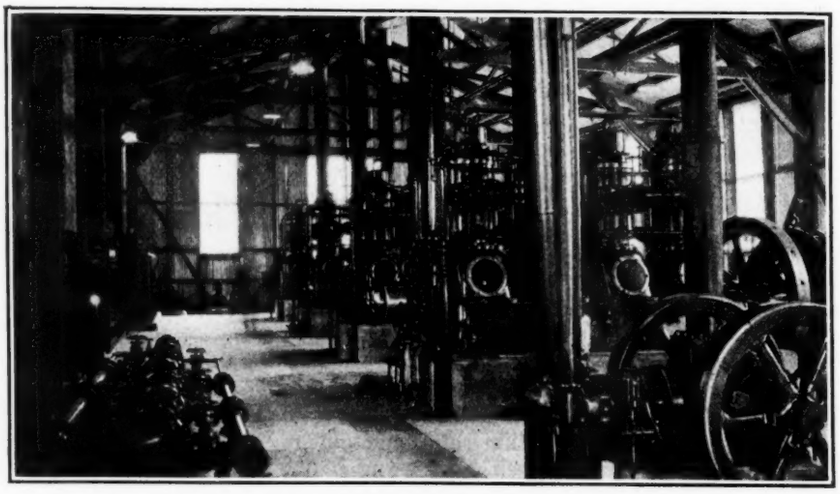


Fig. 2—Showing main engines, circulating pumps and 15-hp. stand-by engine

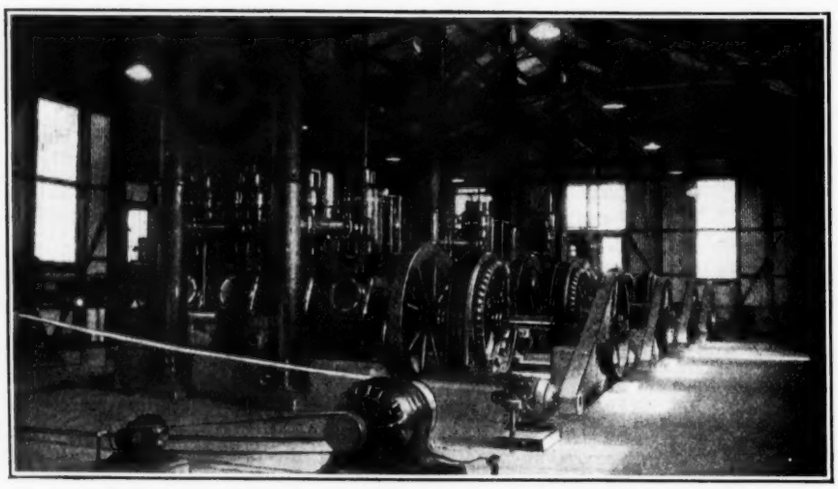


Fig. 1—Four 200-hp. oil engines installed in the Palisade rock crushing plant

These two plants are the largest west of the Mississippi River, each one being designed to crush 100 carloads (3,300 cu.yd.) of rock per 10-hour day. Each plant is equipped with one No. 10, one No. 9, two No. 7½ and one No. 6 gyratory crushers, all driven by motors, the aggregate rating in each plant being 640 hp. To give flexibility of operation, the machinery is so arranged that each plant consists of two separate and complete units. If the production runs ahead of requirements, one unit may be shut down; likewise, in case of repairs the complete plant need not stop crushing.

At each installation the power house is located about half a mile from the crushers, the electric cables running in wooden troughs to the central station.

In the Lucien plant the company installed three 300-hp. 6-cylinder engines. Each engine is direct connected to a 250-kva. 460-volt three-phase 60-cycle alternator, the 10-kw. exciters being belt driven from the extended shafts. In addition an auxiliary 15-hp. oil engine is belted to a 10-kva. alternator to provide lighting during the time the large engines are not on the line.

The equipment in the Palisade plant is the same except that the main units are four 200-hp.

Since fuel economy and maintenance charges were the deciding factors in the choice of the power units, shortly after the Lucien plant was placed in operation, tests were conducted by the Southern Pacific engineers in company with representatives of the engine builder, Fairbanks, Morse & Co., to determine the fuel consumption. Owing to the lack of uniformity in the crusher load, barrel water-rheostats were used in conjunction with the motor load. Readings were taken every ten minutes, and from these the fuel consumption, load, etc., were computed. It was found that, depending upon the load, the kilowatt-hour output per barrel of oil ranged from 331 to 415. During the tests 1,915 horsepower-hours were obtained on a consumption of one gallon of lubricating oil.

Tests at Palisade Plant

The tests made on the engines installed at the Palisade plant were more extensive and more conclusive in their results. Using Richfield oil, 386 to 445 kw.-hr. were produced per barrel, while 26-deg. Union Diesel oil

gave 423 to 482 kw.-hr., the difference being due to the unusually tarry character of the former fuel.

The results of the tests at the several loads are shown in the table.

The engineers of the Southern Pacific estimate that, compared to a steam-driven plant of like capacity, the oil engines effect a saving of 13 cents per cubic foot of rock delivered to the bins with a plant output of 100 carloads a day. This represents a daily saving in power of $423. These comparisons are based on the records made by the most modern steam plant operated by the Southern Pacific, which plant consumes a barrel of oil per 215 kilowatt-hours. Taking into consideration the somewhat higher price of the fuel oil used by the engine, the net saving represented in the cost of the fuel is about 65 per cent.

TESTS OF FAIRBANKS-MORSE TYPE Y ENGINES AT PALISADE, ROCK-CRUSHING PLANT

Engine No.	Per Cent Full Load*	Duration of Test, Minutes	Generator Output Kw.-Hr.	Exciter Kw.-Hr.	Kw. Output of Engine	Hp. Output of Engine	Fuel Burned During Test, Lb.	Lb. of Fuel B.Hp.-Hr.
4	100	30	114.8	4.23	124.84	167.34	40.	0.477
4	100	25	121.68	4.28	132.29	177.33	33.64	0.455
4	100	30	116.8	4.35	127.03	170.28	40.5	0.475
4	100	30	116.8	4.22	126.36	169.3	38.75	0.457
4	50	25	62.2	3.86	68.28	91.52	19.75	0.517
1	100	30	115.4	4.69	125.57	168.32	41.5	0.493

* Altitude, 5,000 ft. Full rated horsepower, 170.

The Evils of Close Regulation in Automatic Combustion Control

By T. A. PEEBLES*

Automatic regulating devices fulfill many duties in the power house. Close regulation is desirable from the viewpoint of production or utilization. On the other hand, it tends to introduce wear, hunting or surging, and other undesirable conditions. This is particularly true of combustion-control apparatus, as herein described.

AUTOMATIC devices are applied in many ways to the processes involved in generating steam. While constant steam pressures appear desirable, there are evils introduced in aiming for this goal only. Undesirable results attending the close regulation of governing devices were discussed some months ago in *Power* by H. M. Phillips. The recent progress in automatic combustion-control equipment makes the closeness of regulation a pertinent issue.

It has been the practice for years to employ a device responsive to changes in steam pressure for regulating the fuel and air supply, and unfortunately the closeness with which this maintained the steam pressure has been taken as a measure of the performance of such devices. If the chart from a recording pressure gage showed practically constant steam pressure, it was assumed that the regulation could not be improved upon.

As a matter of fact, unless the load conditions are unusually steady, the maintenance of a practically constant steam pressure may indicate not good regulation, but on the contrary the very poorest kind of regulation. In order to maintain uniform steam pressure, it is necessary to make a large adjustment in the rate of fuel and air supply for a slight change in pressure.

This pressure change may be brought about by slight variations in load, which could be compensated for by a correspondingly small change in the rate of fuel and air supply. Instead of making this slight adjustment, the regulator that maintains constant steam pressure would have to make an adjustment of fuel and air supply entirely out of proportion to the change in the load.

There is a rating for every boiler and stoker unit at which it will give the best over-all economy, and this load can be increased or decreased only at a sacrifice in economy. It will therefore become apparent that if the load actually carried by the boilers be allowed to swing over a wide range for the sake of maintaining a uniform steam pressure, a loss in economy is inevitable.

When a pressure regulator opens up wide in response to a slight drop in steam pressure, it quickly restores the pressure to the normal amount, but in doing so, produces a number of undesirable results, of which the following are most important.

First, the sudden increase in rate of combustion causes the water level in the boiler drum to rise owing to increased evaporation. The feed-water regulator checks or completely shuts off the supply of water. This further increases the tendency of the water level to rise and delays the opening of the feed. The rate of steam generation is increased both by the higher rate of combustion and by reason of the fact that no water is entering the boiler to be heated to steam temperature. All heat absorbed goes into the actual production of steam. As a result the pressure is quickly brought back to the desired point and the pressure regulator closes, checking the draft to the minimum. The water level drops and the feed-water regulator is prevented from performing its proper function of feeding water continuously and varying this feed in accordance with the demand on the boiler. It is instead responding to the action of the pressure regulator in a manner that makes proper regulation of the feed impossible.

Second, erratic variations in combustion rate and in the delivery of water to a boiler produce irregular superheat, and it is impossible in the design of superheaters to take care of such conditions in such a way as to maintain this uniform.

Third, sudden variations in the rate of combustion result in alternately heating and cooling the furnace brickwork, with serious results. If unnecessarily high rates are employed, furnace temperatures will at times exceed the point to which they would go if smaller loads were maintained. These periods are followed by those of low combustion rate, with the result that slagging and spalling of furnace brickwork will be greatly aggravated.

Fourth, during periods of high combustion rate the circulation of water in a boiler is rapid. Suspended

*Chief engineer, Hagan Corporation.

matter is carried by this circulation into all parts of the boiler, and during periods of greatly reduced combustion rate and reduced rate of circulation through the boiler, these impurities are deposited on all horizontal surfaces.

When the next period of high rate of combustion occurs, these particles are not immediately picked up by the circulation, and they have a tendency to bake on the surfaces, especially those subjected to furnace temperatures. The result is an increase in the number of burned-out tubes, and the blame is often placed on some entirely different condition, when as a matter of fact the regulation is responsible.

Fifth, the tendency of a boiler to deliver wet steam increases with the rating. Heavy loads increase the dangers of foaming and priming, which in many cases are taken care of by blowing the boilers down an excessive amount instead of by correcting the regulation that is responsible for the trouble.

Sixth, practically all boiler and stoker combinations have a rating above which they cannot be operated without production of smoke. Periods of abnormally high loads tend to produce smoke even in cases where the average load is well within the capacity of the boilers and stokers to operate smokelessly. The carrying over of cinders also becomes excessive at such times.

Seventh, the burning fuel is at a temperature that would quickly fuse the entire grate surface if the air supplied for combustion did not cool the metal before entering the fuel bed. During periods of increased combustion the fuel-bed temperature is abnormally high, and when the regulator reduces the air flow to a small amount, the cooling effect is so small that the metal parts of the stoker are overheated. Increased stoker maintenance results.

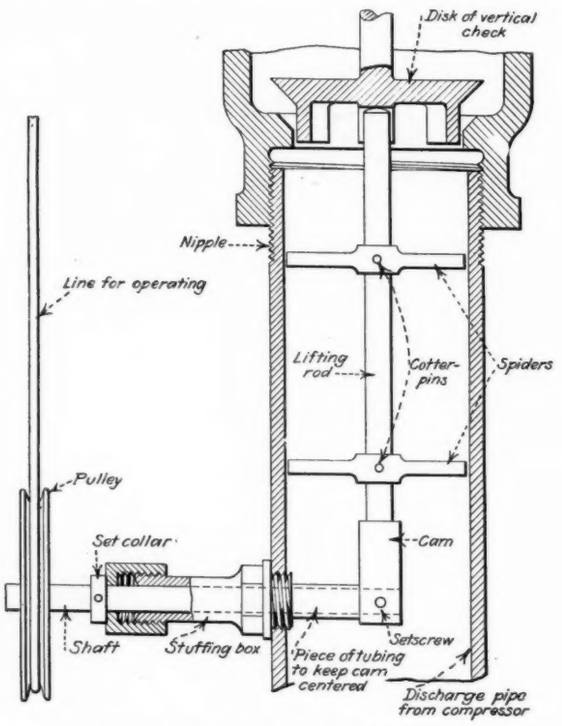
In the adjustment of a system of combustion control, the operator should decide what range of pressure variation is possible without introducing unsatisfactory conditions of operation with engines, turbines and other steam-using equipment. The regulating equipment should then be designed so as to operate over this range and the combustion rate should never attain maximum or minimum until the full allowable pressure range has been reached. In practically every case it will be found that this pressure range will be sufficient to permit the regulating equipment to operate without introducing any of the objectionable features just outlined, and it can in fact reduce all these undesirable ones to a point below that which can be secured by hand regulation.

Device for Holding Vertical Check Valve Open

By E. L. Way

A simple but practicable device for holding a vertical check valve open is shown in the sketch. It is made from the following material: Take a nipple the same size as the check valve and put it in a lathe. Then remove the stuffing box from an old ¾-in. globe valve, drill a hole in the side of the nipple and cut a thread in it to match the thread on the end of the stuffing box. Ream the stuffing box to $\frac{7}{16}$ in. for a $\frac{7}{16}$-in. shaft. Saw off a piece of 1¼-in. shafting ⅝ in. wide to make a cam. Drill the cam for the $\frac{7}{16}$-in. shaft far enough off center so that the stroke will be a little more than the travel of the valve disk. Fasten the cam on the shaft with a setscrew. A piece of tubing placed over the shaft on the inside and a set collar on the outside serve to keep the cam centered in the nipple. The pulley should be at least 3 in. in diameter and fastened on the shaft with a setscrew. The lifting rod is $\frac{5}{16}$-in. round steel with two spiders fastened to it by cotter pins to keep the rod centered in the nipple. The spiders can be made from globe-valve wheels with the rim and one-half of the spokes removed, provided the wheel has six or more spokes.

This device was constructed to operate a 2½-in. vertical check valve on the discharge line from an air compressor driven by belt from a lineshaft. When the steam engine is stopped or slowed down, a ½-in. relief valve, tapped into the discharge line between the compressor and the check valve, relieves the air pressure after the pulley of the device under description is turned so that the valve disk will seat. The purpose of this equipment is to eliminate excessive wear on the check valve and the hammering noise when the compressor is running. After the engine has come up to full speed, the relief valve is closed and the pulley of the device turned so as to hold the valve disk up. The total cost is not much more than the labor of construction, as the material can be picked out of the scrap pile around almost any shop or manufacturing plant.



Arrangement of operating device

Flat steam valves of pumps should always be kept scraped true and the packing rings of piston valves kept free in the grooves. In scraping in flat steam slide valves, the strokes of the scraper should cross, in order that the scraper will not chatter on the narrow bridges between the ports and thus cause steam leakage when the valves are in operation. It is highly important that all the steam valves should be kept tight, for if the control valve leaks, the main steam valve will become steam-bound and the pump will stop.

Regina Municipal Station Makes Good Showing

By E. W. Bull*

In view of the articles that appear from time to time in the columns of *Power* showing the operating results of various sized power plants and of the widespread interest among engineers in the boiler-room bonus, the operating results of the Regina Municipal Light & Power Plant for the year 1923 are presented herewith.

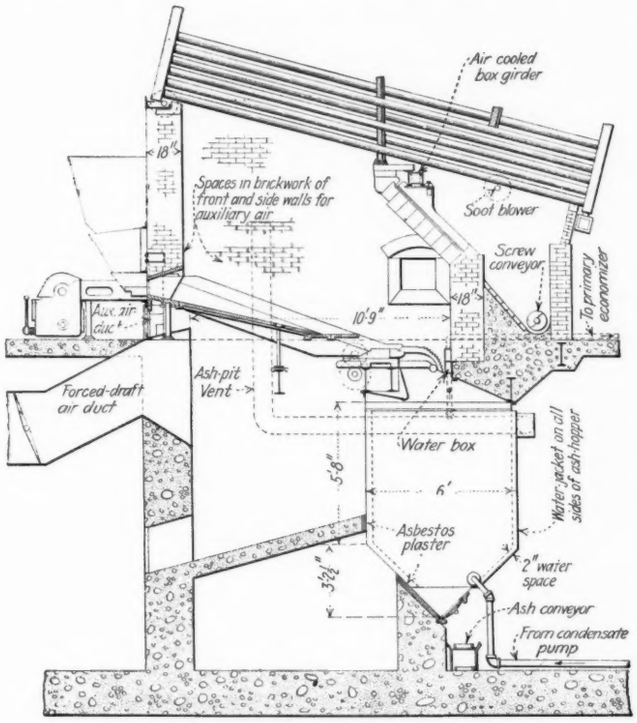


Fig. 1—Cross-section of boiler setting and furnace

The first move in introducing the boiler-room bonus in our plant was to give six of our operators a correspondence course (Hays) in combustion engineering at the department's expense, and when that was finished, we inaugurated a bonus system on the percentage of CO_2 registered in the flue gas and the amount of combustible in the ashpit refuse.

The coal used is tested daily for ash and moisture, as well as the ashpit refuse for combustible content, and the pay of the stoker operator was increased one cent per hour for each 1 per cent CO_2 registered, above a certain standard and also one cent per hour for each 1 per cent of combustible found below a certain standard. This standard was not set at a point where it was difficult to excel, and the result is that the operators are always getting a bonus whether it be much or little, according to their efforts.

The plant carries the entire load of the city, and the generating equipment consists of two 1,500-kw., one 3,000-kw. and one 5,000-kw. units using steam at 200 lb. pressure and 100 deg. superheat. Lake water is available for circulating, and surface condensers are used throughout with evaporators for supplying makeup. A two-effect evaporator of local design and manufacture, giving from 1½ to 2 lb. distilled makeup per pound of steam taken from the boilers, is installed for this service.

The maximum load has been 5,600 kw., and the twelve months of 1923 called for 10,083,150 kw.-hr. to be generated.

The boiler plant consists of six 5,000 sq.ft. horizontal watertube boilers, each having internal superheaters and a feedwater section of 160 twelve-foot tubes installed in the same setting. In addition there is a 320-tube economizer tributary to the main gas flue and operated on the water side under no pressure (as an inverted siphon). The cooling air from the generators is discharged to forced-draft fans at about 100 deg. F. Induced draft is by multi-vane fans and short stack. Four of the boilers are fitted with six-retort underfeed stokers of standard length and two with seven-retort extra-long stokers of the same type, but set one foot lower, giving additional furnace volume. The latter furnaces are fitted with water-boxes at the ash discharge and completely water-jacketed ashpits.

The condensate, after passing the oil cooler on the 5,000-kw. unit, passes progressively through ashpit jackets, water-boxes at the stoker dump, primary economizers, evaporator condenser, feed storage, and finally to the feed pump under a 10-ft. head and from the feed pump to the feed-water section of the boilers under pressure.

Referring to the flow diagram, Fig. 2, the exhaust of the feed pump and the vapor from the second-effect evaporator are condensed in an auxiliary condenser in which the main condensate serves as cooling water. The condensate from this condenser is then passed, together with a small amount from the heater, into the main condenser, where it is flashed and the dissolved oxygen removed.

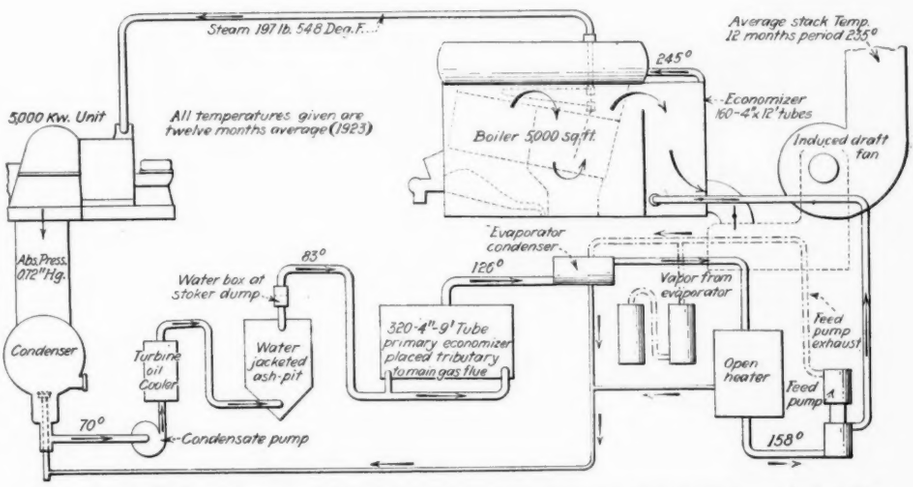


Fig. 2—Condensate flow diagram, showing average temperatures for 1923

Coal is weighed by track scale as cars are received

*Superintendent, Light & Power Department.

and by traveling weigh larries in the boiler room as supplied to stoker hoppers. The accompanying table shows the data of 1923 operations, and during this period the two boilers with seven-retort stokers and water-jacketed ashpits as well as the 5,000-kw. unit were in use over 90 per cent of the time, the two 5,000-sq.ft. boilers being sufficient to carry the load of 5,600 kilowatts.

The fuel burned consists of almost equal quantities of bituminous coal of 7 per cent ash and 1 per cent

OPERATION DATA FOR 12 MONTHS PERIOD 1923

	January	April	July	October	Totals 12 Mos. Period	Ave. 12 Mos. Period
*Coal burned:						
Bituminous, lb.	2,062,000	1,624,940	1,549,000	688,000	18,323,500	.....
Lignite-Drumheller, lb.	1,303,700	245,700	.....	2,909,240	13,171,660	.....
Lignite-Saskatchewan, lb.	.....	1,240,000	1,343,000	664,600	9,047,020	.....
Total coal burned	3,365,700	3,110,640	2,892,000	4,261,840	40,542,180	.....
Kw.-hr. generated	1,854,900	1,471,500	1,372,300	1,733,600	19,083,150	.....
Coal per kw.-hr., lb.	1.815	2.115	2.107	2.458	.....	2.124
B.t.u. per kw.-hr.	21,890	22,690	22,460	23,260	.....	22,880
Feed water per lb. of coal, lb.	8.01	7.13	7.22	5.947	.....	7.053
Feed water per kw.-hr., lb.	14.55	15.07	15.22	14.62	.....	14.38
Temperature of stack gases, deg. F.	229	234	246	228	.....	235
Temperature of gases leaving feed-water section of boiler, deg. F.	366	380	404	373	.....	375
CO_2, per cent	10.88	11.37	10.50	9.85	.....	10.58
Temperature of condensate, deg. F.	57	66	89	64	.....	70
Temperature of feed-water after passing through oil cooler, ashpit jackets, and stoker water-box, deg. F.	72	79	101	84	.....	83
Temperature of feed after passing through economizer, deg. F.	121	130	141	119	.....	126
Temperature of feed after passing through open heater, deg. F.	158	174	177	152	.....	158
Temperature of feed-water after passing through feed-water section of boiler, deg. F.	249	263	264	234	.....	245
Steam pressure, lb.	197	197	.....	.....	.....	197
Steam temperature, deg. F.	540	550	561	548	.....	548
Efficiency of boiler and economizer only	77.4	76.5	78.1	72		76.3
Efficiency of boiler plant [feed taken at condensate temp.], per cent.	83.7	83.5	84.0	79.0	.....	82.0
Temperature of circulating water, deg. F.	40	45	76	51	.....	53
Vacuum, inches of mercury	27.27	27.23	26.73	27.40	.....	27.16
Barometer, inches of mercury	27.78	27.85	27.91	28.01	.....	27.88
Load factor, per cent	47.5	51.7	50.5	43.9	.....	.....
Output taken by electrical auxiliaries, kw.-hr.	113,830	105,710	107,750	112,750	1,285,240	.....
Ratio of auxiliaries to total output, per cent	6.14	7.18	7.85	6.50	.....	6.73

* The average calorific values taken, for the different fuels were: Bituminous, 14,000 b.t.u.; Drumheller, 9,000 B.t.u., Sask. lignite, 6,800 B.t.u.

moisture and 14,000 B.t.u. (probably as good as any in America) and Saskatchewan lignite of 8 per cent ash and 30 to 35 per cent moisture and 6,800 B.t.u. (probably the worst in America) and Alberta lignite of 8 per cent ash and 18 to 20 per cent moisture and approximately 9,000 B.t.u.

The auxiliaries are regularly operated electrically, but the important auxiliaries have duplicate drives. The table shows the consumption of auxiliaries which means every auxiliary that moves electrically in the plant, exciter and plant lighting included.

[This plant was designed by the superintendent, E. W. Bull, and constructed under his supervision during 1914 and 1915. A complete description of the station appeared in the Dec. 7, 1915, issue of *Power*. The primary economizer referred to in the article, which may appear as a rather unusual installation, was reclaimed from the old station which, after the new plant was completed, was converted into a water-pumping plant and substation for street-railway service —Editor.]

Fuel Survey for Buffalo

A fuel program for the City of Buffalo, N. Y., is embodied in a report recently made to that municipality by G. S. Brewer, assistant fuel engineer, Bureau of Mines, and Benjamin Joy Hatmaker, consulting geologist of the Buffalo Department of Public Works. This survey is an outgrowth of a resolution adopted by the City Council under which the Commissioner of Public Works was directed to prepare plans for a municipal gas plant, to investigate the natural-gas conditions of western New York with a view to ascertaining the possibilities of increasing supplies of natural gas. This resolution was the result of an effort to meet a situation characterized by a rapidly failing supply of natural gas with increasing inconvenience to consumers, a high price for manufactured gas and constant litigation with both gas companies over both the conditions of services and the prices charged.

Early in 1922, after the completion of the natural-gas investigation, an agreement was effected between the City of Buffalo and the Bureau of Mines for a study of the entire fuel situation in Buffalo in the hope that the program formulated would offer a rational solution of the problem peculiar to Buffalo and be of value to other cities as well.

Two to two and a half million tons of bituminous coal is used per year in Buffalo. About a million tons is used by coke ovens for making metallurgical coke with byproduct gas, part of which is distributed in the city. The remainder of the coal is used for heating large buildings, for some power purposes and for some industrial heating.

Anthracite consumption is 800,000 tons annually, used mostly for domestic heating. Only very small quantities of coke have been used for any but metallurgical purposes.

Nine billion cubic feet of natural gas is used yearly for domestic purposes. Nine hundred million cubic feet of manufactured gas is annually supplied by coke ovens in and near the city, and by water-gas sets. As to electricity, 464,166,502 kw.-hr. was used in 1922, supplied by Niagara Falls and by steam power.

A general fuel program providing for the most efficient use of the most available fuels involves a policy of more extensive carbonization of soft coal, the gradual substitution of coke for anthracite, the use of gas for all purposes for which gas is pre-eminently suitable, the continued industrial use of bituminous coal where it can be used smokelessly, but the elimination of its use under any conditions that result in the production of smoke.

The present report contains a discussion of factors determining the selection of a gasification plant, a description of the various types of gas-producing plants, a survey of natural-gas resources available for Buffalo, etc. Copies of this report may be obtained from the Department of the Interior, Bureau of Mines, Washington, D. C.

Generator-Field Destroying and Restoring Device

BY RALPH BROWN

For several years the trend in the application of protective devices has been toward the use of relays to isolate quickly a defective transmission line or damaged equipment, since the severity of the effects on the system and the extent of the damage at the point of breakdown will be minimized by quickly disconnecting the faulty line or equipment. However, when very large blocks of power are transmitted, where but one transmission line serves an important substation, or if experience indicates that a large percentage of faults can be cleared by momentarily reducing the system voltage, the use of a field-destroying and restoring device may be warranted.

Such a device, termed a field relay, may be arranged to change the system voltage through the medium of the exciters, but owing to the longer time required by this method, better performance will result if the voltage is reduced and restored by the field circuits of the individual generators being opened and closed. The field relay shown in Fig. 1 was developed several years ago by F. E. Ricketts for uses in the Holtwood plant of the Pennsylvania Water & Power Co., to extinguish arcing ground or short-circuits between conductors by reducing the voltage. Since a decrease in voltage for a brief period will extinguish an arc, provided it will not be re-established when the voltage is increased to normal, operation of the field relay can, under favorable conditions, clear certain faults without causing a service interruption. The field relay cannot clear a fault of a permanent nature, and under certain conditions its operation may cause the generators to pull out of synchronism, thus materially hampering the

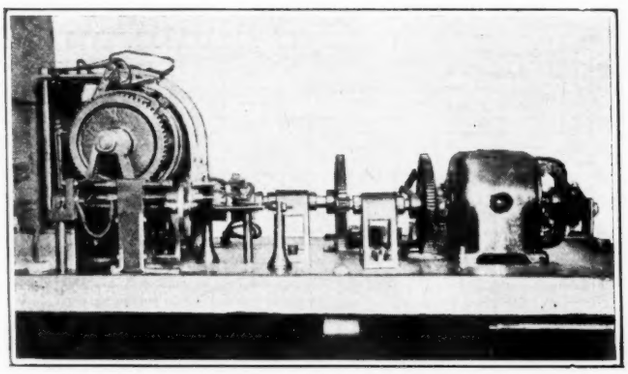


Fig. 1—Field opening-and-closing device

prompt restoration of service, even though the original fault has been cleared.

The manner in which the field relay functions, can be understood by reference to Fig. 2. When a ground occurs on the transmission system or excessive current is supplied by the generators, excess-current relays energize the definite-time relay *T*, which has a setting of four sec. to permit other system relays to possibly clear the fault. If the fault persists for 4 sec. or longer, clutch magnet *M* is energized, this engaging clutch *B*, causing rotation of the disk shaft by motor *A* through worm *C* and gear *D*. The motor operates continuously and is shunt wound to obtain constant speed.

Energizing the clutch magnet closes contacts N_1 and N_2. Current for opening the field switches flows from J_2 to H_2, thence through segment *X* to H_1, and through the switch F_2F_1 to the field-opening contact wire. Since the disk shaft revolves at one revolution per minute, the field switches are opened before *X* breaks the circuit at H_1. The adjustment of contacts H_3 and H_4 is such that they are bridged by segment *X* 1½ sec. after clutch *B* is engaged, thus energizing the closing wire

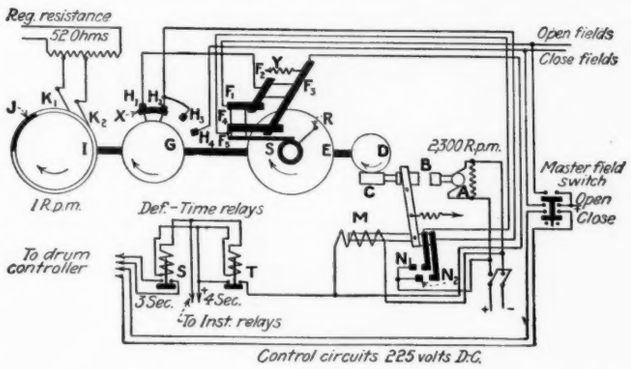


Fig. 2—Diagram of circuits for field opening-and-closing equipment

and closing the field switches after this interval. Contact N_1 is in parallel with the contacts of the 4 sec. relay, it being required to insure one complete revolution of the contact disks. Current flows from N_1 to the metal pin *R* through the collector ring *S*, and as disk *E* revolves *R* strikes switch blade F_3, withdrawing it and F_2 from clips F_1 and F_4 by overcoming the pull exerted by spring *Y*. The disk shaft continues to revolve until blade F_3 slips off pin *R*, thereby opening the circuit to coil *M*, disengaging clutch *B* and stopping the disks in the position shown.

Segment *J* on disk *I* bridges contacts K_1 and K_2 and short-circuits, for a brief period, a section of the resistance in series with the voltage regulator's alternating-current magnet coil. Short-circuiting the resistor by segment *J* in this manner has the same effect as the application of higher voltage to the alternating-current magnet coil, and results in stable action of the regulator during operation of the field relay.

By means of a small double-pole, double-throw knife switch mounted on each generator panel the control wires to the field switch can be connected to the field-relay busbars, or to the control switch placed on the same panel. Those field switches that are connected to the field-relay bus are under the automatic control of the field relay, or they can be simultaneously opened or closed by operating the master field switch shown in Fig. 2. Two additional wires are connected to the master field switch for the purpose of causing the separation of two power systems when it is pulled to the opening position, since the field circuits of those generators operating on one system are arranged to be unaffected by operation of either the field relay or the master field switch. The 3-sec. definite-time relay *S*, is provided for causing automatic separation of the power systems one second before the field relay comes into action. Any field switch connected to a control switch can be operated only by that control switch.

Convenient Analysis of Modern Plant and Application to Ship Propulsion

Net plant efficiencies with stage bleeding or reheating which may be quickly obtained from simple diagrams with appropriate corrections, are of interest to both land and marine practice.

CONSERVATISM was stressed by Eskil Berg, in addressing the Metropolitan Section of the A.S.M.E. some weeks ago, concerning the advantages of a modern high-pressure steam plant as applied to ship propulsion. In spite of the fact that reheating would prove beneficial, and probably practical as subsequent discussion brought out, this was not included in the 550-lb. 750-deg. 40,000-kw. plant for propulsion. The bulky piping characteristic of reheating equipment of the present time, though not a necessity, might be cited as an objection to the entire scheme. While

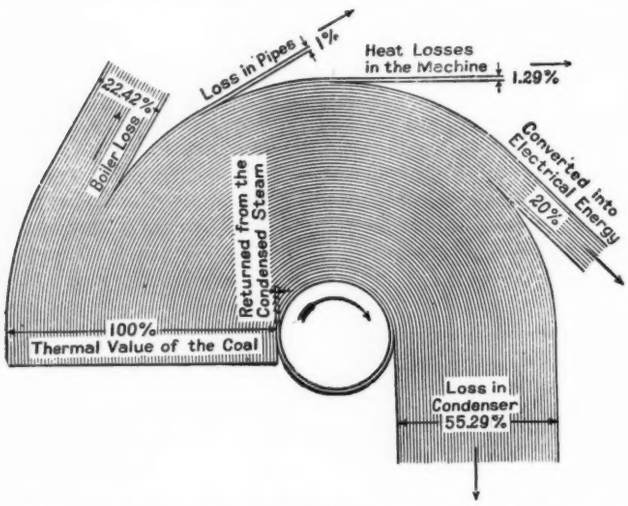


Fig. 1—Twenty per cent of energy is available with 250-lb. 200-deg. superheat steam

allowing for heat and electricity, as required for ship use, a shaft horsepower per 0.55-lb. of fuel oil is deduced.

The plants of a few years ago delivered a kilowatt with fourteen pounds of steam going to the condenser. With the adoption of high pressure, superheat, reheat and bleeding, this figure can be cut to less than half, which means that the condenser loss per kilowatt-hour is similarly reduced. Since the steam turbine today has reached a point of development where its efficiency is within a small percentage of that theoretically obtainable, power-plant improvement has been along the lines of heat cycles rather than improvement of the prime mover.

Increasing the steam pressure gives more available energy in the course of expansion to the usual vacuum. The total heat in a pound reaches its maximum at 370 lb. absolute, remaining constant to 395, and decreasing slightly to 1,200 lb. In spite of the fact that the total heat lowers between 395 and 1,200 lb., more energy is available from expansion under these conditions. In raising from 200 to 1,200 lb., the total heat is reduced 1.58 per cent, while the energy is

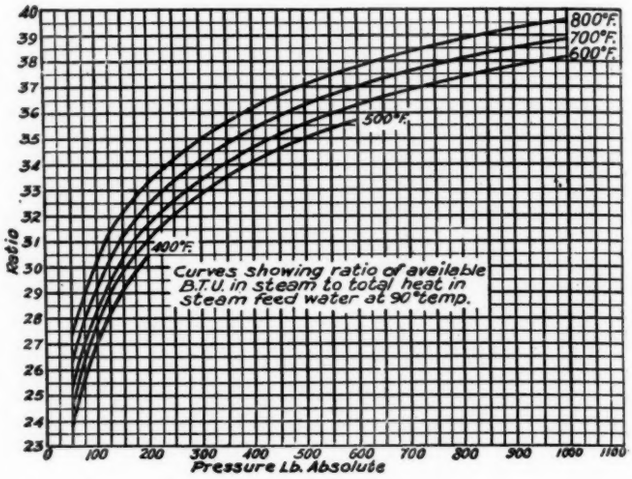


Fig. 2—Ratio of theoretical available energy in fuel with 90 deg. feed water

increased about 24 per cent, which means a net theoretical gain of 25.5 per cent.

In Fig. 2 the ratio of the available energy in steam expanded to a 28.5-in. vacuum, giving credit for returned feed water at a temperature of 90 deg. F., is shown. This represents a perfect prime mover and

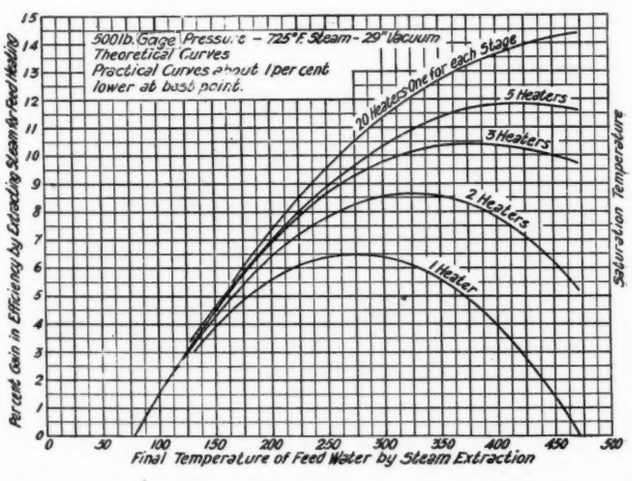

500 lb. Gage Pressure – 725°F. Steam – 29" Vacuum
Theoretical Curves
Practical Curves about 1 per cent lower at best point.
20 Heaters One for each Stage
5 Heaters
3 Heaters
2 Heaters
1 Heater
Percent Gain in Efficiency by Extracting Steam for Feed Heating
Saturation Temperature
Final Temperature of Feed Water by Steam Extraction

Fig. 3—Extraction gain figured at 500 lb., steam, but correct within 2 per cent from 200 to 1,000 lb. with usual heaters

boiler. Its application to a plant of average steam conditions of 250 lb. 200 deg. superheat is indicated in Fig. 1. Twenty per cent of the value of the coal is converted into electrical energy. This may be derived from Fig. 2, which gives 32.8 per cent with perfect

boilers and turbines. By assuming 61 per cent as an over-all plant efficiency for the best conditions, we find that 20 per cent of the power energy is available as electricity.

The theoretical gains by steam extraction for heaters when bleeding at 1, 2, 3, 5 and 20 stages, are indicated in Fig. 3. These curves are calculated for 500 lb. gage, 725 deg. F., and 29 in. vacuum. They can be used with comparatively small error for other pressures and temperatures. Taken in connection with Fig. 2, a plant using the extraction cycle may be approximated in efficiency by assuming the proper boiler, prime mover and other losses.

If the steam admitted is initially dry and saturated, the gain would be larger than is shown in Fig. 3, by several per cent. If the curves in Fig. 3 are used for 200 lb. pressure, 20 heaters, they will read 3 per cent high, but if for only three heaters, 1 per cent, and correspondingly less for fewer heaters. For 1,000 lb. is 35 per cent. If feed-water heating to 290 deg. is employed with three heaters, the gain should be 9.8 per cent, from Fig. 3. The available energy ratio therefore would be 9.8 per cent greater than 35, which is 38.5 per cent. Multiplying this by the assumed prime-mover efficiency of 76.7, we find that 29.5 per cent of the energy is available without consideration of boiler, auxiliary or piping losses.

In Fig. 5 we obtain from Fig. 2 for 550-lb. 725-deg. steam, a ratio of 37 per cent. Feed-water heating with three heaters to 300 deg. gives 10 per cent gain. The ultimate ratio is then 10 per cent more than 37, which is 40.7 per cent. Multiplying this by the prime mover unit efficiency of 76.7, we obtain 31.3 per cent as the ratio of available energy without the consideration of boiler auxiliary or piping losses. These and other incidental losses should be included in order to conform to practical conditions.

Reheating the steam after it has passed through part

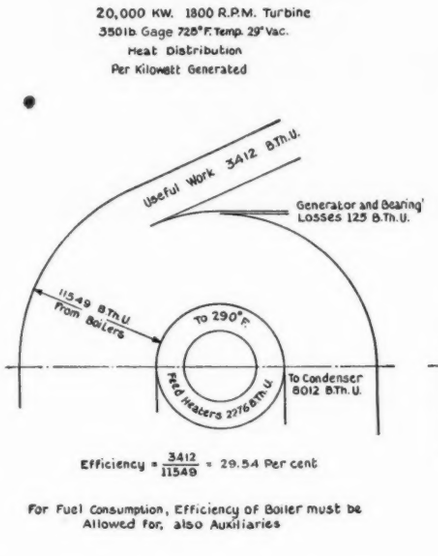

20,000 KW. 1800 R.P.M. Turbine
350 lb. Gage 725° F. Temp. 29" Vac.
Heat Distribution
Per Kilowatt Generated
Useful Work 3412 B.Th.U.
Generator and Bearing Losses 125 B.Th.U.
11549 B.Th.U From Boilers
To 290° F.
Feed Heaters 2276 B.Th.U.
To Condenser 8012 B.Th.U.
Efficiency = 3412/11549 = 29.54 Per cent
For Fuel Consumption, Efficiency of Boiler must be Allowed for, also Auxiliaries

Fig. 4—Bleeding cycle returns heat; efficiency of boiler and piping not considered

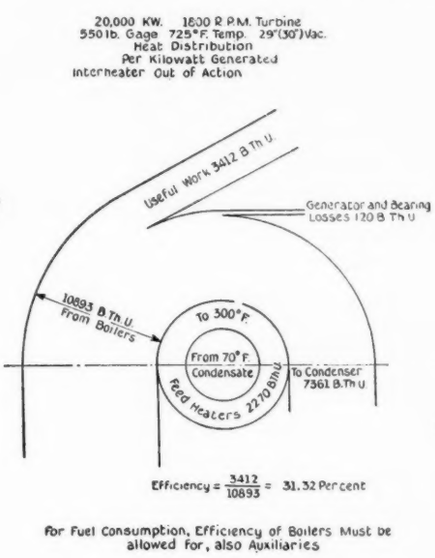

20,000 KW. 1800 R.P.M. Turbine
550 lb. Gage 725° F. Temp. 29" (30") Vac.
Heat Distribution
Per Kilowatt Generated
Interheater Out of Action
Useful Work 3412 B.Th.U.
Generator and Bearing Losses 120 B.Th.U.
10893 B.Th.U. From Boilers
To 300° F.
From 70° F. Condensate
Feed Heaters 2270 B.Th.U.
To Condenser 7361 B.Th.U.
Efficiency = 3412/10893 = 31.32 Per cent
For Fuel Consumption, Efficiency of Boilers Must be allowed for, also Auxiliaries

Fig. 5—Higher pressure and temperature give better efficiency than in Fig. 4

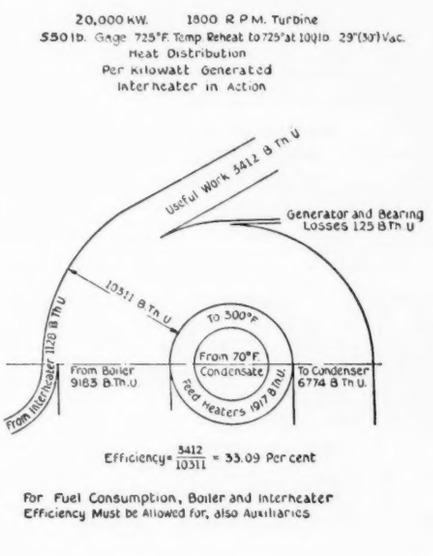

20,000 KW. 1800 R.P.M. Turbine
550 lb. Gage 725° F. Temp Reheat to 725° at 100 lb. 29" (30") Vac.
Heat Distribution
Per Kilowatt Generated
Interheater in Action
Useful Work 3412 B.Th.U.
Generator and Bearing Losses 125 B.Th.U.
10311 B.Th.U.
From Interheater 1120 B.Th.U.
To 300° F.
From 70° F. Condensate
From Boiler 9183 B.Th.U.
Feed Heaters 1917 B.Th.U.
To Condenser 6774 B.Th.U.
Efficiency = 3412/10311 = 33.09 Per cent
For Fuel Consumption, Boiler and Interheater Efficiency Must be Allowed for, also Auxiliaries

Fig. 6—Reheating gives 5.5 per cent gain in efficiency over that in Fig. 4

these are from 3 to 1½ per cent low for the range between 20 and 3 heaters. In practice two to four heaters are ordinarily used, so that Fig. 3 is sufficiently accurate for quick approximation, at ordinary pressures.

Stages for extracting steam are selected in accordance with the temperature range between that of the condensate and the ultimate temperature of the feed water for the boiler. The steps of extraction are usually laid off at equal temperature intervals, as near as possible. The first extraction is ordinarily at 3½ to 4 lb. abs., corresponding to 147 or 153 deg. F. If it is desired to raise this to 300 deg. in three heaters, the remaining 150 would be taken from stages having temperatures of 231 and 306 deg., allowing 6 deg. temperature difference in the heater.

Figs. 2 and 3 can readily be used for approximating advanced steam conditions as in Figs. 4 and 5. In neither case is an allowance made for loss due to boilers, auxiliaries or piping. The prime mover can be assumed at 76.7 per cent efficiency for purposes of illustration, representing here a tentative design. In Fig. 4 we find that for 350-lb. 725-deg. steam the available energy of the expansion in a prime mover and then returning it for remaining expansion, becomes more necessary as pressures are raised. This is because the final temperature is limited by strength of materials. The effect of water condensing in the lower stages becomes more pronounced as steam pressures are increased. The theoretical gain is small, being about 3 per cent when steam is withdrawn at one-fifth of the initial temperature and reheated to the original, while the decrease in water rate is around 4 per cent due to the reduction of friction losses in the turbine. With losses in piping of 1 per cent, the total gain in practice is about 6 per cent.

Figs. 5 and 6 indicate the gains due to bleeding where reheating is also employed. These refer to 550-lb. gage 725-deg. steam and 300-deg. feed water. Without reheating, a kilowatt-hour may be obtained with a theoretically perfect boiler, as shown in Fig. 5. In Fig. 6 the reheaters are placed in action, which give up 1,128 B.t.u. from the boiler to the turbine. The total gain in this case is 10 per cent due to bleeding and 6 per cent to reheating, which is 16 per cent. Boiler and

piping efficiencies should be considered, for further refinement. It will be seen, from Figs. 5 and 6, that the over-all efficiency is increased from 31.32 to 33.09 per cent.

Superheat gives a theoretical gain that is almost negligible as given in Table I. There is, however, a comparatively large gain practically as a result of superheat, which reduces greatly the friction losses in the turbine. Moisture in the steam is a great source

TABLE I—ACTUAL GAIN BY SUPERHEAT IS GREATER THAN THE THEORETICAL

Steam conditions, 250 lb. to 28½ in. vacuum

Deg. Superheat	Temp. Deg. F.	Avail. Heat	Corresponding Ft., Lb.	Total Heat	Per Cent Increase in Fuel to Produce Superheat	Per Cent Increase Available Energy Due to Superheat	Net Theo. Gain, Per Cent	Decrease in Water Rate, Per Cent	Actual Gain, Per Cent
0	406	369.9	288,000	1,201.1	.....	.....	.....	..	....
50	456	381.4	297,000	1,233	2.66	3.11	.45	4	1.34
100	506	393.5	306,000	1,264	5.25	6.38	1.14	8	2.75
150	556	405.9	316,000	1,292	7.57	9.74	2.17	12	4.43
200	606	418.7	326,000	1,320	9.90	13.22	3.32	16	6.10
250	656	431.8	326,500	1,346	12.08	16.75	4.67	20	7.92
300	706	445.3	347,000	1,374	14.40	20.4	6.00	24	9.6

of friction loss. The addition of superheat reduces the moisture greatly and therefore the friction loss. As steam pressures are raised, while temperatures are limited by physical conditions, there is some tendency to decrease superheat. Table II shows the losses in a well-designed turbine for both saturated steam and 200 deg. superheat. It will be seen that the friction loss, which is 20 per cent, and therefore the principal

TABLE II—SUPERHEAT REDUCES LOSSES IN A WELL-DESIGNED TURBINE

	Loss, Per Cent	
	Saturated	200 Deg. F. Superheat
Loss due to friction in nozzles and blades and windage	20	15
loss of disks and blades		
Steam-leakage loss	3	3
Rejected energy (due to residual steam velocity)	3	3
Bearings, packing, etc.	1	1
Total loss	27	22
Efficiency of turbine	73 per cent	78 per cent

one in the first case, is reduced to 15 per cent by the application of superheat so that the over-all efficiency is increased from 73 to 78 per cent.

A turbine disk operating at about 10 per cent moisture under certain conditions produces twice as much friction as if surrounded by saturated steam. Fig. 7 indicates temperatures throughout a turbine for 265-lb. steam 250 deg. superheat. The moisture in the last stage is 10.5 per cent; without superheat the moisture would be practically doubled. The stage heat conditions are given in Table III.

TABLE III—COMPARING QUALITY OF STEAM IN VARIOUS STAGES WITH DRY INITIAL STEAM AND THAT HAVING 250 DEG. OF SUPERHEAT

Stages	1	2	3	4	5	6	7	8	9	10
Quality of Steam	Per Cent Moisture									
Dry initially	4.4	6.8	8.15	9.8	11.5	13	14.5	16	17.3	18.7
Quality of steam	Degrees Superheat					Per Cent Moisture				
250 deg. superheat.	160	120	75	30	0.6	2	4	6.5	8	10.5

The ship-propelling equipment would consist of two 0,000-kw. turbo-generators, two 25,000 shaft horsepower synchronous motors for driving the propeller shafts and two 2,000-kw. alternating-current motor-generator sets for furnishing power for alternating-current motor-driven auxiliaries. For steering gear, excitation current and other auxiliary d.c. power, two 500-kw. d.c. motor-generator sets are provided with one 35-kw. d.c. generator for supplying excitation current to the auxiliary a.c. generator when maneuvering in port.

The propelling turbines operate practically at a base load. The four motor-generator sets would be operated directly from the main power generators, except when maneuvering or in port. Auxiliary attachable turbines and a condenser are supplied for operating under these conditions.

The calculated water rate of the main turbine operating under full power is 8.75 lb. per kw.-hr. A shaft horsepower should be produced on 6.725 lb., including motor losses, but not excitation. Alternating-current

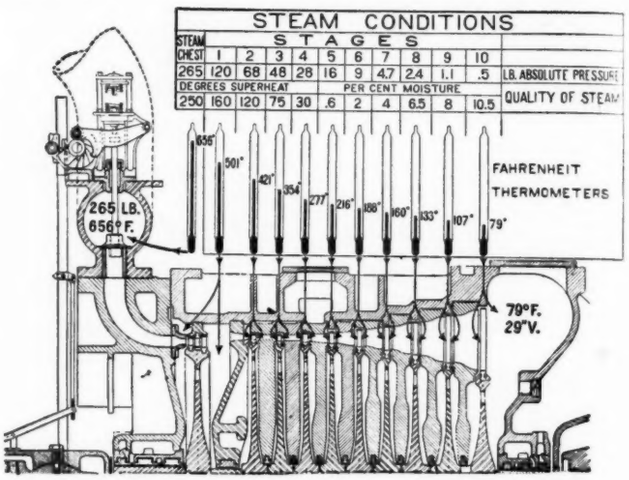


Fig. 7—Superheat reduces moisture considerably in last six stages

power is produced at 10.1 lb. per kw.-hr., and direct-current at 10.35.

Steam for feed-water heating and other purposes is extracted in three sets of 20 lb., 40 lb. and 75 lb. respectively. This heats the feed water successively to 220, 260 and 300 deg. F.

The combined boiler, superheater and air-preheater efficiency is taken as 86 per cent. Table IV gives an

TABLE IV—SUMMARY OF STEAM AND FUEL CONSUMPTION FOR HIGH-SPEED PASSENGER SHIP

Load on main turbine generator	Kw.
Main propelling turbine, 50,000 s. h.p., 97 per cent eff.	38,500
Auxiliary a.c. motor generator set, 1,965.3 kw., eff. 86 per cent	2,270
Aux. d. c. motor generator set, 465 kw., 84.5 per cent eff.	550
Total kw.	41,320
Steam consumption	lb. steam per hr.
Main turbine, 41,320 x 8.75	361,550
Steam admitted in lieu of that extracted for feed water, heating of vessel, etc.	43,700
Air ejector	2,500
Total steam consumption	407,750
Pounds steam per s.hp.-hr. all purposes	8,155
Fuel consumption conditions: Boiler eff., 86 per cent; heat value of 1 lb. of oil, 19,000 B.t.u.; calculated feed-water temp., 300 deg. F.; relative evaporation from and at 212 deg.	16.838
Factor of evaporation	1.1335
Actual evaporation per pound of fuel oil	14.855
Pounds fuel oil per hour	27,450
Tons of fuel per day	294
Pounds of oil per ship horsepower	0.55

analysis of calculations indicating fuel required for the production of a shaft horsepower. Steam for heating the oil, heating the vessel, cooking, and electricity for all purposes are figured in. The subject of reheating is omitted, as the bulky piping might be considered impracticable aboard ship. The propeller speed is 120 r.p.m.; 3,500 lb. of steam and 675 kw.-hr. of electricity, are utilized for ship purposes. Conservative calculation gives 0.55 lb. of fuel oil per shaft horsepower, representing a large saving over direct steam drive, as at present.

Within the Law

"GENTLEMEN," said the promoter, "I have here in this box a most wonderful invention—a machine which, without the expenditure of energy, will produce five-carat diamonds direct from the air."

"Being public spirited, I am going to let you share in the unprecedented profits of this great discovery through the purchase of shares in my company—only a limited number to each person as the benefits must be distributed. A number of millionaires is better for society than a few multi-millionaires."

"Don't crowd. There is plenty of time."

And the promoter chuckles to himself. He knows that he does not have to produce the diamonds, and as long as he refuses to open the box and disclose anything tangible that could be proved unworkable by experts, he is perfectly safe. People may say that his claims are empty, but he cannot be enjoined unless his device can be proved fraudulent. But how can such proof be submitted if he refuses to open the box? and the law as constituted in many states cannot compel him to do this and thereby disclose his secret. No patent is necessary.

Meanwhile he can keep on talking and will find plenty of people with sporting proclivities, gullible enough to part with their hard-earned cash in the hope of becoming independently wealthy.

In this age of accomplishment things are common place which a few years back would have been regarded with suspicion. Hence the popular belief that nothing is impossible.

Incidentally, some readers may be interested (not financially, we hope) in a case that has just been tried in the courts of New York State. Upon the complaint of the "Better Business Bureau" the Attorney General of the State brought suit to enjoin the Tomadelli Corporation from continuing to sell stock in its "bottled sunshine lamp." This, according to the self-proclaimed inventor, can be made to burn for years at practically no expense by using energy from the atmosphere. The lamp has not been produced. The device is said to be locked up in the inventor's safe.

The state produced such well-known electrical engineering authorities as Dr. C. O. Mailloux, past-president of the American Institute of Electrical Engineers, and Dr. Clayton H. Sharp, of the New York Electrical Testing Laboratories, both of whom testified as to the absurdity of the claims. But these were opinions only. They were not permitted to see the lamp or anything connected with its production and thereby disprove its workability, and in his refusal to produce the device the inventor was protected by the law. Apparently, the judge had no alternative but to decide that the state had failed to prove a case of fraud. It is announced that the case will be appealed.

After all, are not the people better protected in certain states that have "Blue Sky Laws"?

Kinks in the Parsons Line

AWHILE ago our esteemed British contemporary, *The Engineer*, figuratively staged a melodrama entitled "The Parsons Line." Some echoes of this performance reached the pages of *Power*. This Parsons Line, which is a useful device much more widely known and used in Great Britain than here, is analogous to the Willans Line, and is obtained by plotting the fuel consumption of a plant against either the water evaporated or the kilowatt-hours produced in the same period. It is customary to use the fuel consumption as ordinates. The discussion mentioned centered about an attempt to plot a complete Parsons line for the Lakeside station by simply drawing an average straight line through a few test points made at good loads. This procedure was defended editorially in *The Engineer* as strictly scientific, and American engineers were asked to explain why a line so drawn happened to cut the fuel axis below the origin, indicating some power consumption with no fuel consumption.

The "problem" ceases to exist when the main assumption is analyzed. For some unknown reason it was assumed as an absolute law that the Parsons line must be straight. Neither theory nor practice upholds such a view except as a rough approximation. At high ratings, in particular, the Parsons line begins to curve upward. It is therefore evident that a straight average line drawn through a few points representing high-load tests has little meaning when extrapolated to the origin. All this is more fully explained and illustrated in the article "Is the Parsons Line Straight or Curved?" on page 8.

Possibly the British impression that the Parsons line is straight is due to that fact that in that country boilers are rarely operated at an output above the point of maximum efficiency. American experience has shown repeatedly that the efficiency eventually starts to fall off as the load is increased above this.

Another application recently made of the Parsons line is not mentioned in the article, but is worthy of comment. The statement was made that "all evidence goes to show that load factor by itself has no influence at all upon the thermal efficiency of a station. The annual coal consumption of a given plant, producing a given annual output, will be quite independent of the uniformity or otherwise with which the output is generated." If the Parsons line is assumed to be straight, this statement is *literally* correct just as it stands, but the conditions of comparison are entirely artificial. In practice (neglecting any curvature of the Parsons line) the load factor has an enormous influence on thermal efficiency. The point is that the statement quoted holds only for a *given* plant with a *given* annual output. Now consider two cities, each requiring the same total number of power units in a year. City A has a load factor of fifty per cent, and city B one of

twenty-five per cent. As a result City B must build a plant of twice the capacity of A. The larger plant will have a different Parsons line; in particular, its stand-by fuel consumption will be larger. So, in spite of the fact that the efficiency of a given plant with a given yearly output will be but little affected by the load factor, it will somehow happen that low-load-factor plants, as a class, will show a lower thermal efficiency than high-load-factor plants. This would still be true even if it were not the custom, and properly so, to construct the low-load-factor plants more cheaply.

A Move in the Right Direction

NIAGARA FALLS early in the history of this country began to serve the power needs of man. In 1725 the French pioneers built a sawmill, which was operated from a canal taking water from the river above the Falls. But it was not until near the end of the last century that the art of hydraulic engineering had advanced so far that engineers felt competent to attempt utilizing this great source of power on a large scale. Since that time rapid progress has been made and developments that are among the greatest in the world have been carried out on both the American and Canadian sides of the river. When present developments are completed, over a million and a half horsepower in hydraulic turbines will have been installed in these plants, although under the present diversion treaty water is available for producing about a million and a quarter horsepower. Considerable of the additional capacity is represented by plants held as reserve capacity, having been replaced by more efficient stations operating under higher heads.

It is significant that two hundred years after the first use of Niagara's water for power purposes, we should be considering how to utilize this great cataract to our best interests. The total flow of the Niagara River 210,000 cubic-foot seconds under the 327 feet fall between Lake Erie and Lake Ontario represent theoretically approximately eight million horsepower. With the present state of the art of hydro-electric development it would be commercially possible to produce about six and three-quarter million horsepower from this water. Unlike most rivers the Niagara has practically a constant flow and is capable of producing power twenty-four hours per day every day in the year, which makes it possible to produce forty-four billion kilowatt-hours annually if the load were available at one hundred per cent load factor. This is equivalent to the power generated by all the central stations, both steam and water power, in this country last year. To produce this power from coal, allowing the low figure of one and one-half pounds per kilowatt-hour, would require thirty-three million tons.

These figures show the potential possibilities of Niagara Falls as a source of power. In addition to being one of the greatest sources of water power in the world, it is one of the most magnificent and majestic of the world's natural wonders, and probably more persons visit the Falls each year for the express purpose of seeing this great masterpiece of nature than any other in the world. These great power possibilities and this unparalleled scenic beauty have brought about conflict of interests between those who can see only the natural beauty of the falls and those who would also have part of the water serve the material need of the people. Undoubtedly, there is a middle course which will make Niagara benefit the greatest number and at the same time save the Falls from the destruction that is slowly going on at the present time.

To this end the engineers of the Niagara Falls Power Company have constructed a large model of the Falls on which any suggestion regarding a greater diversion of water for power purposes as well as remedial works for diffusing the water over the Horseshoe Falls to prevent erosion can be tried out, as reported in last week's issue. Many schemes have been promulgated, but up to the present time there has been no way of proving them out, consequently those suggested by notoriety seekers and probably the outgrowth of vivid imagination had a standing with those of the trained engineers who had made comprehensive studies of the problems and were conscientiously endeavoring to do a creative work. Now this condition has been changed and the different proposals must stand the test of sound engineering principles. Niagara Falls is of too great importance both in the industrial development of this country and Canada and as a natural wonder to apply any guesswork in its future utilization, and the providing of means whereby proposed plans of future development can be tried out is a most constructive undertaking.

Profit in Central Steam Heating

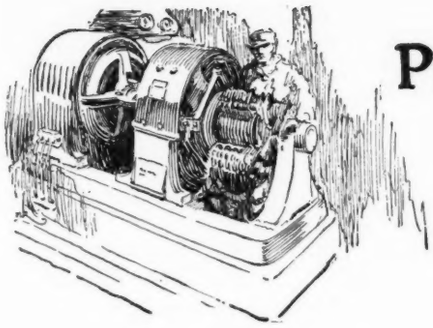
CENTRAL STATION heating is regarded in some quarters as having been weighed in the commercial balance and found wanting. Returns from twenty-five companies indicated that thirteen regarded it as profitable according to the report of Committee on Operating Statistics of the National District Heating Association at the recent New York Convention.

Causes of unprofitable business, such as inadequate rates, few customers per block or undesirable load factors, are well recognized. The chief item of interest lies in the factors that tend to produce dividends.

Discussion indicated that the wastefulness of domestic heating systems as ordinarily operated, represented the main point of attack. Improved heat-regulating devices may be made attractive to the customer financially and likewise productive of better rates to the heating company. The wastefulness of hand regulation as opposed to automatic or semi-automatic means was emphasized.

From some points of view central heating looks more assuring than in the past. Extensions and improvements are going forward, including more efficient utilization of steam in the building, the increase in amounts distributed at pressures around one hundred pounds, and the furnishing of power and heat in combination.

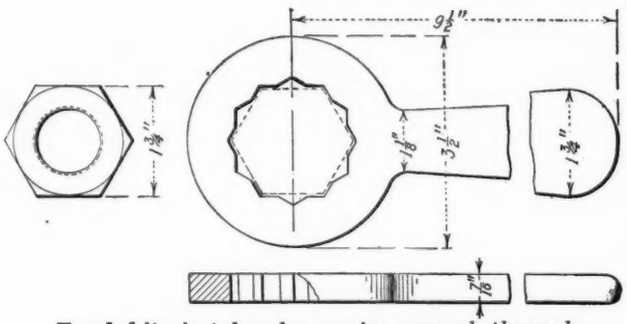
From the point of view of fuel cost and conservation it now appears more necessary to utilize the heat that large power plants reject into the cooling water. The combined power and heating requirements of a community are more deserving of consideration than each taken separately, without respect to the other. In many cases heating and power demands can be utilized in one plant to give a smoother curve of combined boiler load than if supplied individually. Higher steam pressures, such as six hundred to twelve hundred pounds, will make it possible to furnish bled steam at one hundred to three hundred pounds pressure. Centralization of the power and heating with respect to community distribution offers an alternative to the decentralized type of large power station.



Practical Ideas *from* Practical Men

Wrench for Removing Pump Valve Studs

The illustration shows the details of a wrench that I had made recently, for removing the studs from the suction and discharge valve decks of our pumps, and I have found it convenient in such small spaces as valve



Fresh bite is taken by moving wrench through an angle of 30 degrees

chambers where only short bites are possible. The dimensions given are for a 1¾-in. hexagon, but of course could be varied in proportion for other sizes.

Kearny, N. J. ALBERT R. BICKNELL.

Materials for Sealing up Cracks in Castings and Cementing Joints

Although the following points regarding materials used for sealing up cracks, cementing joints, etc., are familiar to a large number of engineers, there are undoubtedly many young men in the field to whom they may prove of value.

Aside from proprietary mixtures, red and white lead, litharge and glycerin, sal ammoniac and iron borings or lathe turnings, or just plain sal ammoniac have proved effective for this purpose. I have known large sand holes in cast fittings to be plugged successfully with litharge. If the cavity is completely filled with the litharge and given sufficient time to set, a tight job will result. Of course the filling must be done from the inner surface of the fitting, and the litharge must also have a backing of metal, or the pressure may blow it out.

Cracks in the walls of pressure vessels may be patched by bolting on a plate with a thickness of sal ammoniac and iron borings beneath it. Many an external firebox sheet has been patched in this way. I once tested a cast-iron cylinder for a hydraulic press in which the iron was so porous that, under 2,000 lb. pressure, the water ran down the outside in rivulets. I filled the cylinder with water, put in a lot of sal ammoniac and let it stand for a couple of days. At the end of that time the cylinder was perfectly tight.

The sal ammoniac treatment has been used in railroad shops for stopping cracks in bushing cylinders. I know of one instance, in particular, where an 18x22-in. cylinder was patched that way. It was an old cylinder that had been bored out and a cast-iron bushing inserted. A coat of white lead was spread on the outside of the bushing and after it was in place it was stayed to the cylinder wall by drilling holes through the wall and bushing and screwing in brass plugs.

Some time later a crack running lengthwise between the plugs in the outer shell opened up for about 15 in. This was made tight by removing the piston, closing the ends of the cylinder and pouring a sal ammoniac solution through the ports until the cylinder was full. This was allowed to stand for ten days, then the cylinder was drained and refilled with a weak solution of muriatic acid and allowed to stand again for about ten hours.

The purpose of the muriatic-acid solution was to complete the work begun by the sal ammoniac. It was presumed that the acid would cut away the coating of rust produced by the sal ammoniac, and that the particles would gravitate toward the pressure. And apparently, this is what happened.

Regarding white lead, I have used it in making up threaded pipe joints and when pressing the brasses into locomotive driving boxes, placing driving pins in the wheels, etc. In the latter case the white lead acts as a lubricant while you are doing the job, and later on, after it has set, it serves to cement the part you have pressed in. For many uses red lead is preferable to white, and I consider it next to litharge for holding anything. If you make up a threaded pipe joint, say a 2-in., with white lead, after a year's time it will still be possible to remove the fitting, but if you make up the same fitting with red lead, and if you wish to take it off after the lead has hardened, it is a foregone conclusion that you will have to break the fitting unless sufficient heat can be applied to cause it to loosen from the pipe.

Then we have the well-known mixture of graphite and cylinder oil to smear on gaskets, pipe threads, etc. Of course, the only purpose in putting this dope on a gasket is to enable the joint to be taken apart later on without tearing the gasket, no cementing being expected. Neither does a cementing effect result when you use graphite on a pipe thread. With graphite on a thread a fitting can be made up tighter than would otherwise be possible. Also, the graphite is squeezed compactly into the interstices in the joint and its very compactness holds it against blowing out under pressure, but it does not anchor the fitting. Therefore, no greater stress is necessary to remove the fitting at any time, than was used in putting it on.

Of course we all know what litharge will do. It has been my experience that it will make a threaded pipe joint absolutely leak-proof against any kind of fluid and against any pressure that the pipe will stand.

St. Louis, Mo. A. J. DIXON.

Piston Out of Level With Crosshead Caused Heavy Pound

Some time ago a pound started in a large Corliss engine whenever a heavy load was carried. With a normal load the noise was reduced. The trouble seemed to be in the crosshead but careful adjusting made no improvement. Engineers know how difficult it sometimes is to locate such a noise even with the use of a stethoscope; this proved the case in this instance for it failed to indicate the source of the knock. We examined the wristpin brasses and found them to be properly adjusted. The piston did not strike at either end and no shoulder had been worn in the cylinder. While examining the piston, we discovered it was about $\frac{1}{32}$ in. low, so we raised it about $\frac{1}{16}$ in. to allow for future wear. This change eliminated the no-load noise, but increased the heavy-load thump. Further inspection showed us that raising the piston had brought it out of level with the crosshead. After resetting it to a corrected level the trouble was permanently removed and the engine ran without noise. J. E. NOBLE.

Toronto, Ont., Canada.

Speed Regulation of Underfeed Stokers

One of the latest fads in power-plant operation is stoker speed regulation. Power-plant operators are now being told that to secure the highest boiler efficiency the rate of coal feed must be kept always proportional to the rate of supply of air to the furnace. The boiler furnace is being likened to a chemical mixing tank in which, to secure a uniform concentration of the chemical in the solution leaving the tank, it is only necessary to add the chemical in amounts proportional to the quantity of water added.

It is my opinion that these ideas apply very well to the combustion of powdered fuel and oil, but I do not

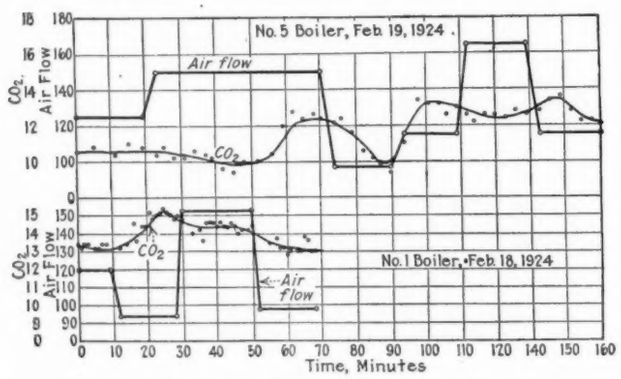


Fig. 1—Per cent of CO_2 obtained with various rates of air flow

think they have application to the combustion of coal on underfeed stokers.

The rate of combustion in a stoker-fired furnace is proportional to the rate at which air is passed through the "live" portion of the fuel bed. The amount of excess air in the products of combustion is determined by the relative proportion of the total air supplied that passes through the "live" portions of the fuel bed. Although it is true that if the rate of combustion is maintained higher than the rate of coal feed for any length of time the "live" fuel bed surface will be reduced and the percentage of excess air will be increased, it does not by any means follow that where the excess air is high the rate of coal feed should be made relatively higher. In fact, it frequently happens

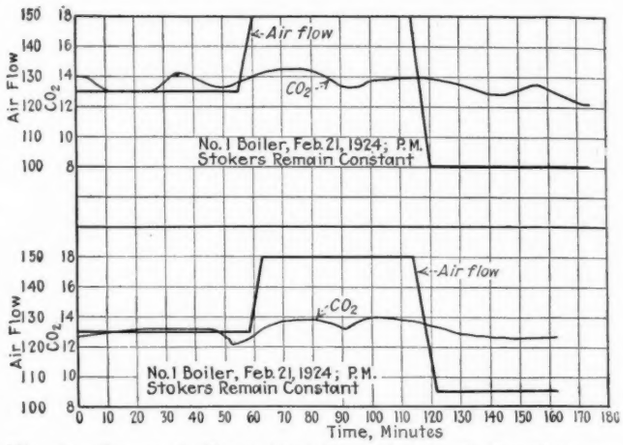


Fig. 2—Curves indicate that there is no relation between rate of air flow and CO_2 over short periods

that high percentages of excess air are obtained when the fuel is abnormally thick and a large amount of fuel is stored on the grates. In these cases the combustion can usually be improved by operating with a relatively low rate of coal feed and allowing the fuel bed to become less thick. The amount of fuel stored on the grates of an underfeed stoker is so great that the stoker can be operated for long periods of time with a rate of coal feed relatively greater or less than the rate of combustion without causing an appreciable change in the percentage of excess air.

Figs. 1 and 2 show the results of tests made on a large underfeed stoker. In these tests the stoker speed was maintained constant while the rate of air flow was varied. The curves show the per cent of CO_2 obtained with the various rates of air flow. The tests showed that after operating for periods of 20 or 30 minutes with an air-flow rate considerably greater than that corresponding to the rate of coal feed, the CO_2 percentage was increased almost as frequently as it was decreased. It will be seen from the curves that over short periods of time there is no relation between the rate of air flow and the CO_2 percentage. It cannot be seen how the combustion would have been improved if the stoker speed had been kept proportional to the rate of air flow.

Even with automatic stoker-speed regulation it would be necessary to observe the fire once every 15 or 20 minutes in order to proportion properly the relative rate of coal feed or air flow to the different sections of the stoker so as to keep the fuel even. It has been shown that without automatic stoker-speed regulation the stoker can be operated for periods of 20 or 30 minutes with an air flow disproportionate to the rate of coal feed without affecting the efficiency of the boiler. Therefore it would seem logical to conclude that automatic stoker regulation will neither increase the efficiency of the boiler nor decrease the amount of attention that must be given to the furnace by the fireman.

Pittsburgh, Pa. J. E. RICHARDSON.

Comments from Readers

Blowoff Pipes for Steam Boilers

With reference to recent articles in *Power* on blowoff piping failures, Mr. Pakes, in commenting on this subject in the May 13 issue, seems to have missed the point at issue.

The 4-in. pipe referred to in my letter of the Feb. 12 issue was used without protection of any kind while the 2-in. one was amply protected so far as my plant is concerned. Another plant with which I am familiar has four 2-in. pipes without protection, but I should not care to assume the responsibility of such practice.

New Haven, Conn. W. H. WAKEMAN.

Hydro-Steam Elevators Give Satisfactory Service

I think Warren Hilleary's article on "Difficulties with Hydro-Steam Elevators," page 939, June 10 issue, does an injustice to a useful type of apparatus, as his experience apparently has been with one of the less successful makes. The choice of an elevator drive is governed by a number of considerations, the most important being to have the source of power available at all times during which the elevator may be required, after which the remaining factors of cost of installation, operating expense and repairs must be balanced against the number of trips per year to produce the lowest fixed charges and operating cost per trip.

From structural considerations, steam pressure usually available, desirable diameter and stroke of the power cylinder, steam-hydraulic elevators are usually built for medium loads and lifts and moderate speeds in freight service—that is, up to three or four tons capacity and 50 to 60 ft. lift at about 60 ft. per min.—though where conditions warrant these limits can be considerably exceeded. This type of elevator requires little attention except an occasional filling of the lubricators on the steam valve and inspection of the packing, and has a number of other desirable features for an apparatus operated by unskilled labor. Chief of these are that, if tampered with, the valves will usually not co-ordinate and the car remains locked or will only descend slowly, the travel of the piston in the cylinder governs the motion of the car and provides a positive stop against overwinding and straining of cables or mechanism if safety switches, etc., do not function. The hydraulic cylinder provides a positive stop by which the car can be brought to exactly the right level at landings for trucking heavy loads on or off the car, instead of the operator having to make an allowance for the brake slippage, and perhaps jockeying up and down several times before landing at the floor.

The company with which I am employed has in operation three electric and two steam-hydraulic elevators, of various capacities and lifts. Our experience has been that the steam-hydraulic elevators give much less trouble and require fewer repairs than the worm-gear driven electrics which comprise our other equipment. We have found the steam-hydraulic elevator with vertical pressure tank of comparatively small diameter and vertical cylinder set side by side within the surge tank, the car equipped with multiplying sheave on the ropes and the pressure tank exhausting to atmosphere with the car descending, the most satisfactory type in economy of space and steam consumption.

The precautions of arranging the steam supply line so that large slugs of water will not accumulate in it is so elementary that it should not be urged seriously as an argument against this type of elevator. It is necessary to have a steam pipe of ample size and without too many bends or steam-using apparatus connected to it to maintain full speed and power to the full lift of the elevator, particularly with high-lift machines. Owing, however, to the comparatively short time during which steam is supplied, the total weight of steam used per day is small.

The writer therefore believes that for anyone having steam available, installing an elevator for occasional use in a dirty place by unskilled labor, where loads are not too heavy or lifts too great, will find the steam-hydraulic elevator well worth considering.

New Haven, Conn. H. D. FISHER.

Making Clear Ice

In *Power*, June 3, 1924, R. G. Summers states that in his large raw-water freezing tank the ice freezes clear, while in his small tank it has a milky appearance. He asks for a remedy.

Assuming proper size air valves, the trouble is doubtless due to inadequate air supply to the small tank. That in the large freezing tank one air valve feeds a pair of 300-lb. ice cans, while in the small one each can has its own supply, does not account for the difference in the rate of air agitation. If a low-pressure gage or a U-tube be connected to the air-supply terminal of each tank, a difference will be discovered, showing that the pipe to the small tank is obstructed somewhere, possibly by a restricted fitting, by water, or that it is too small for the work. Of the 544 cans in the plant 336, or 62 per cent, are in the large tank and 208, or 38 per cent, in the small tank. Allowing 0.55 cu.ft. of free air per minute per can, the total air required is 300 cu.ft. per min. The output of the plant at 13.6 cans per ton is 40 tons per 24 hours.

Air is being compressed in a rotary blower to 5 lb. gage, although 3½ or 3 lb. should suffice. With 60-deg. inlet-air temperature the discharge will be at least 105 deg., and the horsepower theoretically required is 5.9, or including losses a 10-hp. motor is required. The volume of the air after compression is about 240 cu.ft., which means that at 2,000 ft. per min. initial air velocity, the size of discharge opening must be $240 \div 2{,}000 = 0.12$ sq.ft., say a 5-in. pipe. Dividing this up into two branches, one should have 62 per cent of the area, say a 4-in. pipe, and 38 per cent or a 3-in. pipe is needed for the small tank. If pipes smaller than

these are used, the volume moved by the blower is diminished and the pressure and horsepower go up.

To secure satisfactory results in the small tank, each can there must receive the same quantity of agitation air as is being supplied to the cans in the large tank. Possibly the large tank can be robbed for the benefit of the small one by using a gate valve in the 4-in. line. The blower is now unable to meet the demand for air, and during peak load in summer the conditions will be worse.

It is stated that the cooling water has been shut off from the air cooler, because the tubes leak. This means that all the moisture in the air must now be forced through the air piping. Under these conditions the air laterals must be frequently drained. Air, in becoming cooled in the laterals, precipitates moisture. The moisture in 300 cu.ft. free air at 70 deg. F. and 70 per cent relative humidity is 0.239 lb., and in 240 cu.ft. at 40 deg. and 100 per cent, 0.0978 lb.; the difference is 0.1412 lb. per min., or over one gallon of water each hour. This moisture condenses in the piping and collects at low points, which should be at the delivery end and not at the feed end.

It is unfortunate that the air is not precooled. Thus the refrigerating machine has to remove heat, part of which could be absorbed without cost by the spent condenser water. The amount of this heat can be roughly estimated as follows: 300 cu.ft. $\div$ 14.51 = 20.7 lb.; the temperature drop is 105 — 75 deg., while the specific heat of air is 0.24 B.t.u. The heat to be removed is 20.7 $\times$ 30 $\times$ 0.24 = 149 B.t.u. per min. To take care of the latent heat of condensation double this, calling the total 300 B.t.u. These 300 B.t.u. represent one ton of ice-making capacity, being 2.5 per cent of the daily production.

If the cooling water in the air cooler heats up from 70 to 75 deg., the quantity required is $\frac{300 \text{ B.t.u.}}{8\frac{1}{3} \times 5 \text{ deg.}} =$ 7.2 gal. per min.

The condenser water used in the plant should be about 3 gal. per min. per ton of ice, or a total of 120 gal. If all this could be utilized, the 300 B.t.u. would heat it up only for 0.3 of one deg. F., but without special arrangement it is not possible to apply all this water to air cooling.

The amount of leakage in the defective air cooler ought to be determined, and if not excessive the water should be allowed to run and the entire air discharged led to a closed tank strong enough for the pressure, the top head of the tank being provided with 6-in. inlet and outlet openings. The drain cock should be adjusted to keep a water seal over it unless it is convenient to empty the tank intermittently or to use a balanced float valve to regulate the level automatically.

New York City. CHARLES H. HERTER.

Loss of Ammonia in Purging

The purging device mentioned by J. Cassiday in *Power*, May 27, is an improvement upon a very old device. While the builder's statement that no ammonia is lost must be disputed, there is no doubt that this apparatus does save ammonia compared to the usual method of purging at the condenser. This is simply because the chilling of the ammonia reduces its vapor pressure. The air and ammonia will bubble up through the liquid until the pressure above the liquid is, say, 100 lb., of which, with the temperature at 14 deg. F., the ammonia exerts 41 lb. and the air the remainder, or 115 — 41 = 74 pounds.

Obviously, the percentage of air in the mixture passing out of the relief valve is greater than in case of ordinary purging. There is every argument against setting the pressure relief valve at 100 lb.; the apparatus would lose less ammonia if the valve did not blow until the pressure reached a value 5 or 10 lb. below condenser pressure. It is unfortunate that the builder ventured into making his absurd claims of no ammonia loss, for the device is satisfactory and a great improvement over the purge cock. G. GROW.

St. Louis, Mo.

With reference to the purging device mentioned by J. Cassiday in *Power*, May 13, there are several facts that might well be kept in mind when purging from the ammonia system:

Non-condensable gases in the ammonia system are air in nearly every case. Ammonia has not been found to disintegrate during the normal operation of the refrigerating machine.

Leakage of air into the ammonia system takes place usually from carelessness—in permitting the compressor cylinder to carry a pressure below that of the atmosphere, during which time the air leaks through the rod or shaft packing into the cylinder. If the compressor must be operated at less than atmospheric pressure, then extra care or special packing will decrease the leaks.

Air once in the ammonia system cannot be removed without a loss of ammonia.

The loss of ammonia during purging may become very large, but may be reduced by care in purge or by the use of some purging device. If a certain volume of a mixture of air and ammonia exists, the pressure exerted is the sum of the individual pressures exerted by the air and the ammonia if each occupied the same volume separately.

In the case stated by Mr. Cassiday, the volume was 3.5 cu.ft., the temperature in the purger is maintained at 14 deg. F. and the total pressure of the mixture is 100 lb. gage (114.7 abs.). The vapor pressure of the ammonia at 14 deg. F. is 42.18 lb. abs., and therefore the air pressure is 72.5 lb. abs. The weight of the ammonia present is obtained from the specific volume of saturated ammonia, which is 6.7 cu.ft. at 14 deg. F. The weight in the example will be $\frac{3.5}{6.7} =$ 0.522 lb.

Assume that the purging is done in the usual manner and that there is 160 lb. gage condenser pressure (175 lb. abs.), of which 20 lb. is due to air. The specific volume of ammonia at 155 lb. is 1.931 cu.ft., and the weight of ammonia in the same volume as that of the purger, 3.5 cu.ft., would be $\frac{3.5}{1.931} = 1.81$ lb. In other words, there would be nearly 3.5 times the amount of ammonia purged in the usual case, as compared with the use of the special device. In large plants the use of some device is therefore of unquestioned value when purging. In smaller plants it is better to make an analysis into the advantages before installing such a purging apparatus. Of course, useful refrigeration is used in maintaining the temperature required in the apparatus, and this factor increases the cost of operation. H. J. MACINTIRE.

Urbana, Ill.

American and European Hydraulic Turbine Practice

In the May 6, 1924, issue of *Power* Th. Seidl takes exception to the too broad statement regarding the total horsepower of apparatus furnished by the Allis-Chalmers Manufacturing Co. for installation in Japan. In order to correct any misapprehension in this connection and to give more definite information, I am giving herewith a list of the principal installations equipped with Allis-Chalmers hydraulic turbines:

Name	No. Units	Head Feet	Horse-power	Speed R.p.m.	Total H.p.
Mr. Tsuruta, Horizontal Cast Iron	1	140	350	500	350
Kinugawa Vertical Open Flume	1	42	1,430	187½	1,430
Otaki, Vertical Cast Iron	2	300	2,600	500	5,200
Kiso Denki Vertical Steel Plate	3	128	5,800	270	17,400
	1	110	270	870	270
Furukawa, Horizontal Cast Steel	2	340	5,270	600	10,540
Shinyetsu Nakatsugawa Vertical Cast Steel	2	550	13,000	600	26,000
Yahagi Vertical Plate Steel	1	163	10,000	257	10,000
Musashi Vertical Cast Steel	2	235	1,500	500	3,000
Keihin Ryushima Vertical Cast Steel Spiral	2	429	18,000	375	36,000
Oi, Daido Denryoku Vertical Plate Steel	4	137	18,000	180	72,000
	2	119	1,000	600	2,000
Shinyetsu Nakatsugawa Double Overhung	3	1,367	18,000	300	54,000
Total	26				238,190

This list is given as an indication of what but one American manufacturer has supplied in Japan. No statement was made to the effect that the Allis-Chalmers company furnished half a million horsepower. The exact statement was:

> Furthermore, *American manufacturers* are called upon more and more to bid in foreign markets for the largest and most important machinery. For example, *we* sent to Japan, during the last two years, turbines aggregating perhaps half a million horsepower capacity, these covering most of the large and important plants for that country.

The immediate antecedent of *we* being American manufacturers. Naturally, we do not have available information concerning what all other American manufacturers may have done, although we know they have furnished machinery for several large installations. The general statement was made merely on the assumption that it was possible that all other American manufacturers together could have furnished nearly as much as our own company.

W. M. WHITE, Manager & Chief Engineer,
Hydraulic Department, Allis-Chalmers Mfg. Co.
Milwaukee, Wis.

Cost of Bled Steam

It is desired to show how untenable C. E. Colborn's ideas on the cost of bled steam are when one considers the vast field outside the narrow confines of the central station specializing in electricity. In the May 27 issue he takes exception to my remarks as presented on pages 832 and 834 (two articles) of the May 20 issue.

The North pole of the ideas expressed on the distribution of steam costs is evidently the condenser. Everything seems to revolve about that. The central station's classical enigma of "What to do" with the condenser loss is presented in the guise of an industrial plant's power problem. Mr. Colborn says, in principle and in fact, that if the exhaust steam going to the condenser at, say, two inches absolute, can be used, it ought to be *given* away because no additional live steam is required at the throttle to use it.

Suppose some factory that could use large quantities of low-pressure steam is located next door to a central station in order to use this free steam. Then suppose that subsequent condenser development made it profitable for the central station to carry 0.5 in. absolute (instead of 2 in.) and let us further presume that the steam at 0.5 in. absolute was useless to the adjacent factory. Now will the central station give it away at 2 in. absolute? Mr. Colborn will doubtless agree that it will not. In other words the steam cost distribution problem is observed through a central-station telescope having a field of vision only as big as the condenser, trying to scare us by focusing attention on the magnitude of the heat thus thrown away.

Syllogistically, the reasons are like this: Major premise, only heat that is useful for making electricity has value to any body; minor premise, low-level heat is useless for making electricity; conclusion, low-level heat is valueless to everybody.

Again, Why let the tail wag the dog? Certain kinds of industrial "dogs" have no "tails" unless you would classify a heating system or a steam oven as having the same function as a central-station condenser, which they have not. Just suppose there are no condensers at all because the process work demands more steam than the electrical or mechanical load produces. Is a fictitious condenser to be conjured up in order to figure the costs? If the industrial plant eliminates condensers, say by boosting steam pressures to four figures and synchronizing power and heat demands, are we still to hear the refrain, "The condenser loss is there all right. You just can't see it"?

A shield of tradition or priority cannot be used. The truth of the matter is that process steam was an old dog before electricity was even a pup. In most cases this process steam is of basic importance. The process work is going to take so many heat units, and it is not nearly so particular as a turbine or an engine as to where it gets them. But have them it must. So the logical course is not to figure process steam or heat as a byproduct of electricity, but to figure each on the basis of what it actually takes in the way of heat.

Figure how much fuel the process work or heating will take and, following this, how much more fuel will be required to furnish electricity. This is, in effect, merely prorating heat costs according to the heat used. Of course I realize it is enough to give a conscientious central-station engineer a cold chill to see an anæmic, wheezing industrial plant (but they are not all that way) get a kilowatt-hour on the heat equivalent of, say, three pounds of steam when the best he can do—working to the second place of decimals—is 9.

On attempting to make capital of my statement that the bled steam is 44 per cent cheaper than live steam, it must be remembered that the reduction of cost is one thing and the proper distribution of that reduction quite another. The distinction is vital and was made in the article to which I refer.

So far as "inducing" the use of bled steam is concerned this is—to borrow one of Mr. Colborn's adjectives—absurd. This was covered on page 832 of the May 20 issue. It is an engineering problem to ascertain if bled (or exhaust) steam should be used. It is a management problem through provision of proper facilities, records and supervision to see that it is used. Does the management of a central station have to "induce" the fireman to use a poorer grade of coal after the engineering staff has ascertained beyond question there is a real saving in the offing? You can bet your last B.t.u. it does not! GUY B. RANDALL.

Dayton, Ohio.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Heat Equivalent to Horsepower-Hour

How many heat units are equivalent to one horsepower acting for one hour? *A. F. M.*

Carefully conducted experiments have shown that taking one British thermal unit as the mean heat required to increase the temperature of 1 lb. of water per deg. F., between 32 and 212 deg. F. gives

1 *mean B.t.u.* = 777.54 *standard foot-pounds*

The quantity is called the mechanical equivalent of one heat unit and, for practical computation, usually is taken as 778 foot-pounds. One horsepower = 33,000 ft.-lb. per minute, or acting for one hour 33,000 × 60 = 1,980,000 ft.-lb. Hence 1,980,000 ÷ 778 = 2,545 B.t.u. are equivalent to one horsepower acting for one hour.

Shutting Down Steam Turbine

In shutting down a steam turbine, is it advisable to throttle by hand before or after taking off the load? *R. N. D.*

It is advisable to throttle down as the load is taken off. Then, if the main valve leaks, overspeeding will be prevented. This is the usual custom with large units. When the governing mechanism is in good order, this may not be necessary and on small turbines with tight valves, closing the hand throttle is often delayed until the load is removed. Shutting down affords a good opportunity for tripping the emergency valve by hand to determine whether overspeeding occurs at no load, and to test the emergency, after which the throttle can be closed tight.

Action of Governors on Electric Elevators

What is a governor in connection with a car safety device on an electric elevator? Is there more than one kind of governor? How is the safety device actuated when the car overspeeds? *W. H.*

Centrifugal-weight governors are generally used on traction elevator machines and on most other modern machines, but a large number of side-cam governors are also in use. The weight governor is so arranged with shafting, gears and cams that the centrifugal force, when the car overspeeds, causes the weights to leave their normal position, and this has different effects with different governors. On the high-speed traction elevator the governor first short-circuits a portion of the shunt-field resistance, but if the car continues to overspeed, the governor next opens the circuit through the potential switch, which disconnects the motor from the line. If for any reason the car should not instantly slacken speed, a tripping device will be actuated and suitable jaws will catch the governor cable, stop it and cause the safety device under the car to grip the guide rails and stop the downward motion of the car. Probably the most reliable of all types of governors under all conditions of operation, repair, adjustment, cleanliness and general maintenance is the type where the weights revolve with a vertical spindle or shaft. Side-cam types and weight types, when the latter are mounted on a horizontal shaft, are not so reliable, except under ideal conditions of maintenance. The function of the governor which is equipped with an electrical switch is, first, to open the switch should the car overspeed, and second, to cause the gripping of the governor cable. The final function of any governor is to cause the gripping of the governor cable.

Losses in Transformer

When a 5-kw. transformer is connected to a 2,300-volt line with the secondary side open—that is, on no load—what would be the loss in this transformer for 30 days and what figures are used to determine these losses? *E. F. F.*

The losses in a transformer will depend somewhat on its design. However, the no-load losses in the 5-kw. transformer referred to did not exceed 3 per cent of the unit's capacity. Therefore, the losses in this transformer would amount to 5 × 0.03 = 0.15 kw. In thirty days the transformer would be in operation 30 × 24 = 720 hours and the kilowatt-hours represented by the losses in the transformer would be 720 × 0.15 = 108 kw.-hr. At 5c. per kilowatt-hour this would amount to 108 × 0.05 = $5.40.

Calculating the Presure in Hydraulic Elevator Cylinders

How is the pressure required in the cylinder of a hydraulic elevator of the multiplying-sheave type, used for passenger service, determined? *W. H.*

On any hydraulic type having multiplying sheaves, the calculation of approximately the maximum pressure necessary may be made as follows:

A. Assume a live load of 110 lb. per sq.ft. of effective car-floor area. This weight is arrived at by taking the average weight per person at 150 lb.; minimum space occupied 14x14 in. or 196 sq.in., equals 0.765 lb. per sq.in. or 110 lb. per sq.ft.

B. Multiply the square feet of effective car-floor area by 110 to get the total live load.

C. To the live load add the unbalanced weight of the empty car to obtain the maximum load to be lifted.

D. Multiply the load to be lifted by the ratio of piston travel to car travel.

E. For a 10 to 1 reduction increase the product of "D" by 60 per cent, for 8 to 1 by 50 per cent, for a 6 to 1 by 40 per cent, for a 4 to 1 by 30 per cent, and

for a 3 to 1 by 20 per cent. These percentages are arbitrary and vary more or less, but are correct enough for practical conditions. They represent the loss through friction.

F. After obtaining the result under "E" divide it by the square inches of cylinder area. The quotient will be the pounds gage pressure required on the system to start a load properly. The pressure required to continue the load in motion is much less than that required to start it.

As an example assume a horizontal-cylinder pushing type, 10 to 1 reduction elevator machine with a 26-in. diameter cylinder:

A. Car floor 5.5 × 5 ft. = 27.5 sq.ft. area.

B. 27.5 × 110 lb. = 3,025 lb. live load, to which must be added,

C. Say 1,000 lb., which makes a total of 3,025 + 1,000 = 4,025 lb. load to be lifted.

D. Multiply the value of "C" by the gear ratio, or 10, the product being 40,250. Increase this by

E. 60 per cent, which gives a total load of 40,250 × 1.60 = 64,400 lb., representing the live load, the unbalanced weight of the car, the frictional loss and effort to first overcome gravity.

F. Divide "E" by square inches of cylinder area, which equals 26 × 26 × 0.7854 = 531. This gives 64,400 ÷ 531 = 121 lb. gage required in the cylinder.

The automatic regulators on the pumping system should be set for 120 lb. and the safety valves set for not over 130 pounds.

Computing Water Power from Second-Feet of Flow

When the flow of a stream is quoted in second-feet, how is the available horsepower computed? *L. C.*

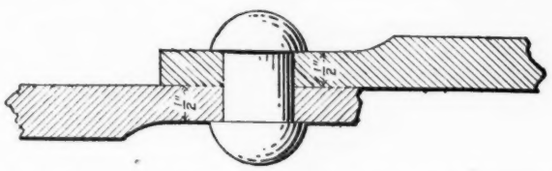
The term second-feet is commonly employed to express rate of flow of water, one second-foot meaning flow at the rate of one cubic foot of water per second of time. To compute the horsepower from the number of second-feet of flow, we must take into account the weight of water per cubic foot and the height through which the water falls.

The weight of one cubic foot of pure water at the temperature of 62 deg. F. is 62.355 lb., and for practical purposes the weight of one cubic foot of fresh water may be taken as 62½ lb. When a flow of one second-foot of water has a fall of one foot, there is development of 62½ foot-pounds per second, and as one horsepower is development of energy at the rate of 33,000 ft.-lb. per minute, or 550 ft.-lb. per second, a flow of one second-foot of water with a fall of one foot would develop work at the rate of 62½ ÷ 550 = 0.1133 hp. Hence, multiplying the number of second-feet of flow available at a site by 0.1133 gives the water horsepower obtainable per foot of fall, and multiplying this product by the number of feet of fall improved gives the gross or water horsepower obtainable. The number of useful horsepower obtainable from the gross horsepower of the water would depend on the efficiency of the water-wheel or other form of water motor employed. As an example, suppose the available flow of a stream is 60 sec.-ft. of water with a developed head of 35 ft. and it is desired to know what number of horsepower could be obtained for driving electric generators, using a turbine waterwheel of 90 per cent efficiency. The gross or water horsepower would be 60 sec.-ft. × 0.1133 × 35 ft. head = 238 gross hp., and, using a turbine water-wheel of 90 per cent efficiency, the net power would be 90 per cent of 238 = 214.2 horsepower.

High Working Pressures for Return-Tubular Boilers

Why are not the usual sizes of return-tubular boilers for power plants more commonly made for higher working pressures than 150 to 175 lb. per square inch? *R. D.*

Constructions that require plates of sufficient thickness for higher pressures are uncommon on account of the greater expenses of material and workmanship and the restrictions of the working pressure required by the design of the circumferential joints. When shell plates exceed $\frac{9}{16}$ in. in thickness, the portion of the plates forming the laps of the circumferential joints, where exposed to the fire or products of combustion, should be planed or milled down to ½ in. in thickness, as shown in the sketch, to prevent injury to the plates from becoming burnt or overheated. This reduction



Circumferential joint for thick plates of horizontal return tubular boilers

of thickness must be taken into account as a limitation of safe working pressure in fulfillment of the standard requirements, that the strength of the circumferential joints in the shell shall be at least 35 per cent of that required for the longitudinal joints when 50 per cent or more of the load, which would act on an unstayed solid head of the same diameter as the shell, is relieved by the effect of tubes or through stays in consequence of the reduction of the area acted on by the pressure and the holding power of the tubes and stays.

Running Blowoff Connections

When the blowoff connection is tapped into a boiler larger than 2½ in., how should the blowoff piping be run and connected? *J. A.*

The blowoff pipe should be extra heavy from the boiler to valve or valves and should be run full size without reducers or bushings, so there may be no points of reduction for wedging of scale or gathering of sediment to choke the pipe. A bottom blowoff pipe, when exposed to direct furnace heat, should be protected by firebrick, a substantial cast-iron removable sleeve, or a covering of non-conducting material, and the opening for the piping through boiler setting should provide for free expansion and contraction. The usual maximum size for blowoff pipe and fittings is 2½-in. In some instances local regulations require blowoff connections 4 in. in diameter for horizontal return-tubular boilers that are over 48 in. in diameter. Where the size of boiler tapping in a shell is larger than the size of the connections, the boiler opening should be provided with a riveted flange, with tapping of proper size for receiving the pipe.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications, and for the inquiries to receive attention.—Editor.]

Here and There in the Power Plant

Sidelights on things generally used but less generally understood

CO_2 with Coal, Oil and Gas

IT IS sometimes thought that a given percentage of CO_2 represents a definite percentage of excess air, regardless of the kind of fuel being burned. As a general proposition this is not true, although the variation is not great for solid fuels. Fuel oil differs substantially from coal in the relation between CO_2 and excess air. Natural gas shows a still greater divergence, while the relation is very erratic with blast-furnace and producer gas.

The differences among the various coals, between coal and oil, and between oil and natural gas are due almost entirely to the free hydrogen contained. The difference between one coal and another or between one oil or natural gas and another is not important in this connection. This is not true of producer gas and blast-furnace gas. They contain many disturbing substances, particularly hydrogen, carbon monoxide, carbon dioxide and nitrogen. All these vary continuously, so that the control of the fire by CO_2 alone becomes difficult. If it were as easy to analyze for oxygen as for CO_2, the former would give a much simpler means of control for such fuels.

The inspiration for this article was a letter received from Texas calling attention to the fact that the CO_2 obtained with natural gas runs only about two-thirds that for fuel oil.

Effect of Hydrogen on CO_2

To make the reason for the differences in CO_2 as clear as possible, attention will be concentrated on the effect of the hydrogen by considering three imaginary fuels practically equivalent (as far as the relation of excess air, CO_2 and gas temperatures is concerned) to actual coal, oil and natural gas respectively.

Table I gives the analysis and heat value of these three imaginary or idealized fuels. Actual analyses would be more difficult to handle, but would give substantially the same final results.

TABLE I—ANALYSIS OF IMAGINARY FUELS

Fuel	Carbon, Per Cent	Hydrogen, Per Cent	B.t.u. per Lb. (Higher)
Imaginary coke	100	0	14,600
Imaginary coal	97	3	16,025
Imaginary oil	90	10	19,450
Imaginary natural gas	75	25	26,475

The imaginary coal, being a "boiled down" essence without ash or moisture, shows a heating value far above that normally obtainable, but the moisture and ash have very little effect on the computations for CO_2 and gas temperatures. The very large percentage of hydrogen in natural gas is due to the fact that its principal constituent is methane, which is three-quarters carbon and one-quarter hydrogen by weight.

When any of these fuels burns completely, the carbon (C) unites with oxyygen (O_2) of the air to form CO_2. The hydrogen unites with another portion of oxygen to form water (H_2O). During its journey through the furnace, boiler and stack this water is in the form of superheated steam, a gas that acts much like the others present, except that it has a higher specific heat. When, however, a sample of flue gas is drawn for analysis, this vapor condenses, so that the analysis does not show the actual composition of the flue gases.

Problems Worked Out

Now let us see what happens when each of the fuels in Table I is burned with 40 per cent excess air. Take first the coke. The formula for carbon burning is

$$C + O_2 = CO_2$$

Parts by weight, $12 + 32 = 44$

Parts by volume, $? + 1 = 1$

The relative weights are nothing but the molecular weights. The relative volumes are equal to the number of molecules. This applies only to gases.

The air supplied contains 21 parts by volume of oxyygen and 79 of nitrogen. There being 40 per cent excess air, the 21 parts of oxyygen supplied will be 140 per cent of that actually burned to CO_2. Then the volume of O_2 burned to $CO_2 = 21 \div 1.4 = 15$ parts. This will produce 15 parts CO_2 and leave 6 parts oxgen and 79 parts nitrogen. Therefore, with this coke 40 per cent excess air corresponds to 15 per cent (by volume) of CO_2.

Take next the case of the "coal" with 97 per cent carbon and 3 per cent hydrogen. The carbon burns according to the formula already given. The formula for the combustion of hydrogen is

$$2H_2 + O_2 = 2H_2O$$

Parts by weight $4 + 32 = 36$

Parts by volume $2 + 1 =$ Zero[1]

As far as the gas sample is concerned, the hydrogen and half its volume of oxygen merely disappear. Assume that 100 parts (by volume) of air are supplied, containing 79 parts of nitrogen and 21 parts of oxygen, of which (as before) 15 parts are burned. The products will then contain 6 parts of oxygen, 79 parts of nitrogen and something less than 15 parts of carbon dioxide.

To figure this last it is necessary to determine how much of the oxygen disappears with the hydrogen. Pound for pound, hydrogen requires three times as much oxygen as does carbon. So the 3 per cent of hydrogen will consume $\frac{3 \times 3}{97 + (3 \times 3)} = \frac{9}{106}$ of the air actually burned. Therefore $\frac{9}{106} \times 15 = 1.3$ parts of oxygen will disappear in this way, leaving 13.7 parts CO_2, 6 parts oxygen, and 79 parts nitrogen. These total 98.7 parts, so the actual percentages are: 13.9 per cent CO_2, 6.1 per cent O_2 and 80 per cent N_2.

By the same method of computation the corresponding figures may be obtained for the imaginary "oil" and "natural gas." These are given in Table II and are close to those obtainable with the actual fuels.

TABLE II—ANALYSIS OF DRY FLUE GAS WITH 40 PER CENT EXCESS AIR

Fuel	Per Cent by Weight Carbon	Per Cent by Weight Hydrogen	Flue Gas Per Cent by Volume CO_2	O_2	N_2
Imaginary coke	100	0	15	6	79.0
Imaginary coal	97	3	13.9	6.1	80.0
Imaginary fuel oil	90	10	11.7	6.3	82.0
Imaginary naturalgas	75	25	8.1	6.5	85.4

This table shows that the hydrogen in fuel oil and natural gas greatly reduces the CO_2 obtained with a given percentage of excess air. That oxygen comes much closer to being a direct measure of excess air is evident from the fact that (in Table II) the variation is only 0.5 per cent from coke to natural gas.

For any of these fuels the expression $100 \frac{\text{per cent } O_2}{21 - \text{per cent } O_2}$ gives a close approximation to the percentage of excess air.

This formula is exact only for a fuel containing no hydrogen, but is very close for the others. Its derivation for a simple carbon fuel is easily seen. Starting with air containing 21 parts (by volume) of oxygen, the carbon is burned turning a certain portion of this oxygen into an equal volume of carbon dioxide. Therefore the total volume of flue gases is the same as that of the air supplied, and the CO_2 and O_2 must add up to make 21 per cent. Then $21 - O_2$ represents the oxygen that was "burned," while O_2 represents the excess that was not used. The ratio of excess oxygen to that burned gives, when reduced to per cent, the excess air.

The small error that occurs when applying this formula to high-hydrogen fuels is due to the fact that the total volume of the flue gas is less than that of the air supplied by the volume of oxygen that burns with hydrogen to form water. As a result the unburned O_2 is a somewhat larger percentage of the flue gas than it was of the original air.

[1] That is, the moisture condenses and does not show up in analysis.

Pitting of Hydraulic-Turbine Runners

The Conclusion Is Drawn from the Experience of Operating Companies That the Chief Factor Governing Pitting of Waterwheels Is the Total Draft Head Acting on the Runner

LAST year a subcommittee with Albion Davis, Mississippi River Power Co., chairman, was appointed as part of the N. E. L. A. Hydraulic Power Committee to investigate the causes of pitting of waterwheels. Letters requesting experience data were addressed to about forty of the leading hydro-electric companies of the United States and Canada, who represented approximately two-thirds of the water power developed. In addition to a statement of the results of operation, detailed information was requested for the different wheel settings, in order that specific speed and total draft head on the wheels might be figured. Up to the time of making its tentative report, the subcommittee had received complete information on about 70 different wheel settings. The following is an abstract from the report which was recently issued:

Two-Thirds of Water Turbine Practically Free of Pitting

The statements made in this report are merely tentative conclusions suggested by the information now at hand. They are purposely left in outline form to bring forth comment and further facts. The finished report should come later, after there has been time to verify and extend the present data.

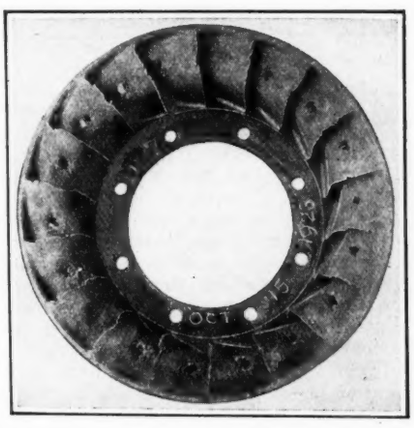


Fig. 1—Most common location of pitting is on the sides of the buckets nearest the draft tube

From the data so far received it is estimated that two-thirds of all water turbines are practically free from pitting. The remaining third have developed pitting in varying degree, some of the smaller wheels with thin blades being eaten through in less than a year, while others of more massive construction lasting for ten to fifteen years, even though pitting has been progressive throughout the period.

The pitting action begins as very fine pits on the surface of the metal, these first pits being sometimes invisible to the naked eye. The action progresses oftentimes to a depth of one-eighth to one-quarter of an inch and enlarges the hole beneath the surfaces in a manner not unlike the way a tooth will decay after the hard enamel is penetrated. The surface is gradually honeycombed by the action until it acquires a spongy appearance entirely free from rust and dirt. In cases where a runner is inspected within two or three hours after the time it was carrying full load, the pitted surface will be bright. It is as though certain parts of the metal had been eaten away by strong chemical action and the harder or more resistive parts left.

Where Pitting Occurs

Practically all of the pitting occurs on the back or vacuum side of the buckets, the most common location for the pitting being in patches on the side of the buckets nearest to the draft tube, as indicated in Fig. 1.

From the replies at hand it is believed that knowledge is distinctively lacking as to the reasons why some wheels pit and others do not.

At the risk of being called to account by those familiar with the entire history of turbine development in this country, the belief is stated that the pitting of turbine runners is the direct result of the demand for more power, more speed and greater efficiency, just as the pitting of steamship propellers was the direct result of the higher speeds demanded by steam turbines.

In the early days little attention was paid to speed or to the setting of the wheel because the big gains were to be made in the efficiency of the wheel itself. Wheels were set at or near the tailwater level and little consideration given to the draft tube. It was only comparatively recently, perhaps within fifteen years, that the use of a draft tube and high setting of the wheel above tailwater came to be accepted as good practice. With wheel efficiencies approaching more nearly the ultimate, in the last few years attention has been turned toward improving the wheel setting and securing higher speeds at low heads.

Changes in Tube Design Result in Increased Draft Head

Radical changes have been made in draft-tube design whereby perhaps three-quarters of the energy entering it can be recovered as increased draft head on the wheel. Such a development of draft tube has made it possible to use higher speeds because of the assurance that the higher velocities resulting at the discharge of the runner could be recovered effectively as draft head. The general result of these rapid strides has been greater draft heads in the runner and more cases of excessive pitting.

The one outstanding conclusion to be drawn from the experience of operating companies is that the total draft head, in the main, governs pitting. More specifically, it is believed that the presence of a nearly perfect vacuum at any point on the surface of the runner causes pitting when this vacuum operates in conjunction with water moving at a fairly high velocity. To put it in a still different form, it is believed that pitting occurs where the main stream of water pulls away from the buckets. In support of this view a number of cases of pitting are cited.

By total draft head is meant the sum of the height of the throat of the runner above tailwater and the draft due

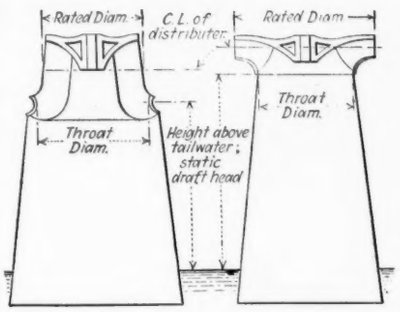


Fig. 2—Dimensions used in obtaining total draft head

to the velocity through the throat of the runner, which would be the point of greatest constriction of the water passage at or near the discharge from the buckets.

Increasing Total Draft Head Increases Danger of Pitting

It is believed that any factor that increases the total draft head at any point in the runner increases the danger of pitting. Thus, if for the moment the matter of runner design is forgotten, the following factors which tend toward more pitting are: (1) Higher specific speed, which means higher velocities in the runner and draft tube; (2) increased capacity; (3) higher head; (4) better draft-tube efficiencies; (5) lowering of the tailwater level. It is apparent also that at the critical point a difference of only two or three ft. in the total draft head can make all the difference between excessive pitting and none at all or between a runner that will last for 25 years and one which will go to the scrap pile in five years.

The matter of proper design cannot, of course, be overlooked. It is possible that by slight modifications in design a wheel that shows moderate pitting can be corrected. The use of more buckets might help this condition, but on the other hand the hydraulic efficiency and the cost of the wheel might suffer. It is believed, on the one hand, that a poorly designed wheel can be set at a low height above tailwater and show no pitting and, on the other hand, that regardless of how well a wheel may be designed with respect to pitting, pitting cannot be avoided if the setting is too high above tailwater.

In the case of turbine runners operating under the higher heads, design of the wheel for the specific operating conditions becomes increasingly important. In these cases operation of the runner at partial gate openings has a greater tendency to create unequal pressure and to increase the draft head locally within the runner. In these cases the range of velocities through the guide vanes is very great and offers greater resistance to conforming to the fixed angles of the buckets than would be the case for lower head wheels. This thought seems to be borne out by the different reports.

Part gate operation or improper design can play an important rôle in building up the draft head locally within the runner. Besides this, in many of the higher-head wheels the draft due to velocity at the throat of the runner amounts to 15 ft. With only a setting of 8 ft. above tailwater there is in these cases very little margin for the avoidance of pitting when the wheel is to be operated at other loads than that for which its water passages were especially designed.

Since the several buckets of a runner cannot overlap each other completely, the stream of water is unsupported on the pressure side after it passes the lip of a bucket but is still in contact with the under, or reduced pressure, side of the following bucket which is concave to the direction of the stream of water. By far the most common locations for pitting are in just such places; namely, on the reverse side of the bucket at or just beyond the lip of the preceding bucket where the water tends to pull away from the surface, Fig. 1.

The effect of unequal distribution of velocities is another factor which can contribute to the development of local areas of high vacuum and which should not be lost sight of. Any obstruction in the path of a stream of water moving at moderately high velocities increases the water velocities around the obstruction and may create a high vacuum immediately adjacent to the points where the stream of water leaves the obstruction on the downstream side.

Pitting of Keokuk Turbines

While not exactly a parallel case to the phenomenon of pitting, it has been noted in the case of the Keokuk turbines that corrosion of the distributor bolts just ahead of the guide vanes is very unequal. These bolts are 8 in. in diameter and stand in a vertical position. The side facing the incoming water and the two sides parallel to the direction of flow of the water as it approaches the guide vanes are very smooth and have shown practically no corrosion while the back side or the side away from the incoming water, has developed a very heavy coating of rust blisters and scale. The contrast was so marked that it would probably be possible to determine quite accurately the direction of flow at different points around the runner from the position of the maximum corrosion and thereby obtain some idea as to the efficiency of the scroll case.

From the literature on ship-propeller pitting it has been noted that if the leading edge of the blades becomes notched due to fouling or accidental blows, pitting is likely to develop in a fan-shaped area in the wake of the notches. Again, unprotected bolt heads will cause clean-cut furrows of pitting on the metal surfaces in the wake of the bolt head.

Dr. O. Silberrad, in *Engineering* for June 28, 1912, sums up his extensive experience with ship-propeller pitting in the opinion that pitting occurs where the rate of change of flow is greatest, as in bends, or angular portions where the water is forced suddenly to change its direction or on curves where eddies are induced.

This thought seems to be entirely in accord with experience in connection with turbine-runner pitting which, so far as effect on the metal is concerned, seems to be identical with ship-propeller pitting.

Thus it would be expected that irregularities of bucket surface, bucket curvature and the distribution of velocities in the runner would all have a bearing on the total reduction of pressure at any particular spot in the runner. While these three effects cannot readily be computed, they should be considered as additive to the bigger, and more easily figured, effect of total draft head as previously defined. This latter figure, of course, represents only height above tailwater and draft due to the average velocity through the throat of the runner. Since all the effects are cumulative, it is extremely likely that in the areas affected by pitting there is a high vacuum. One fact seems certain, namely, that no matter what kind of metal is used and regardless of design, if the total draft head is effective the runner will pit.

Effect of Material on Pitting

The returns show that pitting is not confined to runners in either the high- or low-head classes or to high or low specific speed wheels or to runners having high specific speed with respect to the head; nor is there apparent any distinction as to the manufacturer. Furthermore, pitting is not confined to any particular metal. Cast-iron, cast-steel, steel-plate, bronze, or Monel-metal runners all have pitted and all in similar manner and to approximately the same degree. While there may be some choice of metal on economic grounds, there is little choice as to pitting, at least for moderate heads. One metal may be somewhat better than another, but the difference is small. One company, however, with mostly all high-head wheels, 200 to nearly 600 ft., expresses an opinion against cast iron on account of its short service.

With regard to the comparative merits of the different metals in turbine design, it might be said that the feeling is general that steel runners are desirable from the standpoint of ease of repair by the electric arc welding process.

Methods of Repair

The most successful method of repairing pitted turbine runners yet developed appears to be that of electric-arc welding. Welding by the oxyacetylene process has not proved entirely satisfactory. The chief difficulty seems to be in getting a uniform heat and in preventing shrinkage cracks.

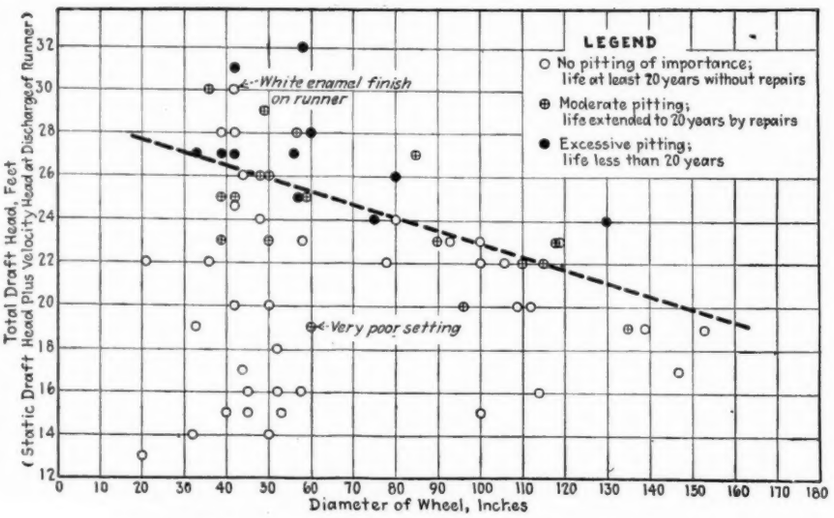


Fig. 3—Effects of draft head on pitting of turbine runners

Larger wheels showed excessive pitting at much lower draft heads than the smaller runners. This observation is strikingly similar to the common experience that a large draft tube will not support as high a water column as a smaller one. The dependence on both pitting and vacuum conditions on the size of the water column immediately prompts the thought that the words pitting and vacuum are almost synonymous.

It is a well-known fact that the size of draft tube determines the length of the water column above tailwater. In a small tube the flow lines are better controlled and the velocity is more uniform across the section, while in the larger tubes there is less to control the flow lines and naturally the distribution of velocities suffers. Temperatures of the water also has an important bearing on the length of column that can be supported. Altitude is still another factor to consider.

It will be noted from Fig. 3 how definitely pitting depends both on the

size of the wheel and on the total draft head. A wheel 4 ft. in diameter may be able to stand a total draft head of 26 ft. without serious pitting, but a wheel 10 ft. in diameter would undoubtedly show serious pitting if the total draft head exceeded 22 ft. While it is realized that the rated diameter of the runner may not be just the right factor for showing the above effect, for the present at least, it serves the purpose. For direct comparison the average total draft head for the nine different groups into which the runners were classified, the condensed table is given.

Probably group II in the table is the best one for indicating the critical draft heads above which pitting becomes serious. Wheels that do not pit may have any draft head down to zero or even be under pressure, and wheels that pit may have any total draft head (up to 34 ft.) in excess of the critical figure. The wheels that pit moderately are, however, just on the border line and theoretically at least should determine the critical points where pitting develops.

Draft Head Due to Velocity

In figuring the draft due to velocity at the throat of the runner, a wheel efficiency of 85 per cent was assumed and velocity at discharge of the draft tube assumed to be balanced by the increase of velocity at the throat due to the cross-sectional area of the buckets. No allowance was made in the computation for the efficiency of the different styles of draft tubes nor for the fact that the distribution of velocities at the throat will not be uniform. The primary object of the computation was not necessarily to secure a mathematically exact figure, but to furnish some reasonably accurate and uniform basis for comparing the different runners as to probable draft at the throat. Fig. 2 shows the dimensions upon which the figures for total draft head were based.

In any wheel, horsepower, pressure head and draft head are continually changing. There are only a few cases where these three factors are even reasonably constant throughout the year. Tailwater elevations in a low-head plant are usually subject to considerable fluctuation. While the static

AVERAGE TOTAL DRAFT HEADS

Size of runners	I No Pitting	II Moderate Pitting	III Excesive Pitting
Up to 48 in. diameter	21.8	25.8	27.6
48 to 96 in. diameter	20.1	24.4	27.3
Over 96 in. diameter	19.5	21.5	24.0

draft head has been given a fixed value, representing probably normal low tailwater, there may be times during the year when the tailwater level goes two or three feet lower, thus increasing the total draft head just as much. As previously pointed out, three feet variation in tailwater level can make all the difference between serious pitting and no pitting whatever.

In working up the data, it was interesting to note sometimes how figures alone would tell the story of pitting. The runners of certain wheels were reported as wearing out extremely rapidly due to a combination of sand and acid prevalent in the water. The static draft head, 16 ft., was apparently low enough. On figuring the velocity head at the throat, however, it was found to be 16 ft., or next to the highest throat velocity head yet found. This gave a total draft of 32 ft., the highest for any wheel yet reported. Assuming the figures are correct, it was no wonder that serious pitting took place regardless of sand or acid.

In another case, a larger wheel, the static draft head was only 7.5 ft. but the throat velocity head was 16.5 ft., giving a total draft head of 24 ft. It is obvious that static draft head in itself does not tell the story.

To show the influence of total draft head on pitting, all the runners have been plotted in Fig. 3, using the three factors, rated diameter, total draft head, and rate of pitting. Runners that show practically no pitting were plotted as plain circles, those showing moderate pitting as crosses inside circles, and those showing excessive pitting were plotted as solid black circles.

It should be noted first of all that the rate of pitting does not vary directly with the draft head, but seems to depend entirely on whether or not certain critical draft heads are reached.

The plotting of the points was much more consistent than was expected considering the data and in view of the other variables whose effects, while indeterminate, should nevertheless be added to get at the true draft head on the runner blades. As shown in the summary table, with increase in size of runner there is a definite reduction in the total draft heads at which pitting occurs.

Critical Head Above Which Pitting Occurs

The dotted line, Fig. 3, was drawn to average the points showing moderate pitting. It might be referred to as the critical line above which there will be definite pitting and below which there will be no serious pitting. All the points above the line except three are cases of either excessive or moderate pitting, and all points below the line except two are cases of either no pitting or only moderate pitting.

The primary object of Fig. 3 was not to determine finally the position or shape of the line, above which pitting occurred, but it was to establish the fact that pitting depends upon whether or not the total draft head is above or below a very limited range of values. Furthermore, it was intended to show that in case of large wheels pitting will take place if the total draft head is not made less than would be permissible in a small wheel. For example, Fig. 3 shows in general that for a wheel 10 ft. in diameter the total draft head should be made less than 22 ft. if serious pitting is to be avoided, while in the case of a wheel 4 ft. in diameter a total draft head of 26 ft. might be allowed without expecting serious pitting.

It is significant that pitting begins to be serious at the same total draft heads beyond which one would expect to have difficulty in maintaining steady flow in the draft tube. The pitting experience not only seems to exhibit the same tendencies as the limits for steady flow, but the actual values appear to be essentially the same. In fact, it would seem that the pitting experience, thus far, furnishes the best quantitative figures for the practical limits of draft head for steady flow. This observation seems to be borne out by the experience data of Fig. 3, notwithstanding the fact that the plotting takes no account of the many minor influences affecting pitting.

The data seem to establish definitely the theory that serious pitting occurs on the surfaces of a runner only where there is a nearly complete vacuum. To go one step farther, pitting is believed to occur where this high negative pressure, or draft head, is so located that it can draw from the passing stream a continuous spray of water and air bubbles containing the destructive oxygen element. Oxygen is released from the water by the reduction of pressure.

That pitting does not occur until the draft head approaches the limit is probably because there is no vacuous space in which the released oxygen can become concentrated. There would seem to be no opportunity for oxygen to concentrate unless the main stream of water actually pulls away from the surface slightly. Otherwise the released air and oxygen bubbles should be swept along by the rapidly moving water.

Summary

The tentative conclusions of this report may be summed up in the following statements:

The primary cause of pitting in turbine runners is high draft head resulting in nearly complete vacuums on the surfaces of the runners. Pitting occurs where the main stream of water pulls away from the surface and where the vacuum draws from the passing stream a spray of water and oxygen released by the draft head. The oxygen becomes highly concentrated because of the violent eddies set up.

Pitting is not confined to any one class or type of turbine runner and does not depend to any great extent on the metal used. Large wheels pit at much lower draft heads than do small wheels.

The principal factors contributing toward the formation of high local vacuums in the runner are in the order of their importance: (1) Height above tailwater; (2) draft due to velocity at the discharge of the runner; (3) design of the runner as to bucket size, angle, and curvature and as affecting both the distribution of velocities and the local tendency of the stream to pull away from the buckets; (4) design of the wheel setting, more especially the draft tube.

From an operating viewpoint, higher speed, higher head or greater capacity; lowering of tailwater or improvement of draft-tube efficiencies; and finally, that which is most important at high heads, operation at gate openings other than those for the best distribution of velocities—all contribute toward the tendency of a runner to pit.

Pitting may be avoided by a lower wheel setting or by any other method which decreases the draft head. Pitting on existing runners may be minimized by building up the affected areas by the electric-arc welding process, using a metal that resists corrosion better than the original metal.

Recent Publications

Elements of Steam and Gas Power Engineering. By A. A. Potter, Dean of Engineering, Purdue University, and J. P. Calderwood, Prof. Mech. Eng. Kansas State Agricultural College. Second edition. Published by McGraw-Hill Book Co., Inc., New York. Cloth; 5½x8 in.; 331 pages; 226 illustrations. Price, $2.75.

By reason of the customary course of entering an engineering college immediately upon finishing high school, the average student has little if any knowledge of the practical side of engineering. Until he enters his senior year, where his studies embrace a fairly close acquaintance with machines and mechanics, it cannot be said that his information as to power-plant machinery shows any improvement. The authors, when preparing the first edition of this treatise, evidently had this deficiency in mind when outlining the scope of the work. They have discussed briefly and concisely the type of prime movers and auxiliaries used in power production. The second edition shows some improvement over the earlier work. A short chapter on units and definitions has been added, and at the end of each chapter are placed a number of questions which should be of assistance to the instructor in bringing out the material in the reading pages. While largely used in school, the volume is adapted to home studying.

Principles of Electric Motors and Controllers. By Gordon Fox. Published by McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York City, 1924. Cloth; 5½x8 in.; 499 pages; 298 illustrations. Price, $3.50.

No electrical subject is of more vital importance than motors and their controllers, since their applications reach practically every ramification of industrial and domestic work. Much has been written on these subjects, especially on motors, but changing conditions and new devices call for new types of motors and controllers or modifications of existing types of equipment, so that this new volume can well justify its existence in bringing, as it does, the subject of motor and control principles up to date. The book is not a theoretical treatise, but presents the subject from the practical side in the language of the man who has to operate this class of equipment.

The first four chapters treat of the direct-current motor, followed by five chapters on alternating-current motors; the chapter on "Speed Control of Polyphase Induction Motors" describes ten different systems in commercial use today. The polyphase synchronous motor has 36 pages devoted to its operation and characteristics. Single-phase motors of various types and polyphase motors of the brush-shifting type have received liberal treatment.

About 50 per cent of the space is devoted to principles of controllers for electric motors and the protection of these classes of equipment. In this section a large number of controllers for use on motors when applied to a wide variety of industrial applications are described. In most cases a complete wiring diagram is given for each controller discussed. A chapter is devoted to each of the subjects, The Use of Flywheels in the Application of Electric Power, Electric Motor Braking, and Electric Brakes.

Throughout, the work is practically void of mathematical treatment and vector diagrams. These have been omitted since there are several good works that treat the theoretical aspect of the subject. At the end of each chapter is given a bibliography of references to literature on the subject discussed.

The principles, construction and performance of electric motors and controllers have been treated, but specific applications are referred to only as they serve to illustrate the application of principles. A companion volume, "Electric Drive Practice," which is now in preparation, will be devoted to the selection and application of motors and controllers. The present book is intended for those interested in the application and operation of electric motors and controllers, and with this class of reader the work should find a wide field of usefulness.

Representative Government in Industry. By James Myers, executive secretary of the Board of Operatives, Dutches Bleachery, Inc. Published by the George H. Doran Co., New York City. Cloth; 5¼ x 7¾ in.; 249 pages. Price, $2.

Usually, books on the human relation in industry reflect either a bitter feeling on the part of a labor writer or an unenlightened view of a capitalist. This book is a very calm presentation of the whole situation as it actually exists. The first chapters are given up to the statement of conditions, while most of the remaining ones are devoted to employee representation in industry. One chapter is "Religion and Morality in an Industrial Democracy," and that the public may not be left out in summing up this difficult question, it has its own chapter. A reading of this clear observation on the actual operation of works councils, with its practical suggestions, should be helpful to those to whom the "next step" in industrial progress is of concern and interest.

The Business Letter-Writer's Manual, by Charles Edgar Buck. Published by George H. Doran Co., New York City. Cloth, 6¼ x 9¼ in.; 232 pages. Price, $3.

Here is a book that hits at stupid and unthinking business letters, which either go into waste basket or file without accomplishing the friendly contact that the opportunity for a letter created. Who has not received from some business concern a letter so lacking in friendly spirit that it has started a bad mood which lasted for an hour or so? Encased in the small symbols for conveying thoughts there goes, unrealized by the writer, his spirit and mood just as surely as goes the inflection in a person's voice over the radio.

Beginnings and endings of letters, word usages and different letters for all sorts of purposes are treated with intelligence. These suggestions offered will be helpful to business men as well as to their secretaries and clerks. A good book to keep on the desk for reference and also for consultation before sending out a sharp or difficult reply.

The Dominion Water Power Branch of the Department of the Interior of Canada has recently issued its annual report for the fiscal year ending March 31, 1923. This report briefly describes the main lines of activity which are pursued by that organization in investigating the water resources of Canada and administering the Dominion water-powers.

Copies of this report will be supplied free of charge on application to the High Commissioner for Canada, Kinnaird House, Pall Mall East, London, or to the Director of Water Power, Ottawa, Canada.

Coal Dealers Truths, by George R. Pratt, A.M.E.I.C., fuel engineer of the Province of Alberta. Published by the Government of the Province of Alberta, which aims to help the coal situation in Canada, is a thoroughly practical little booklet that may be purchased from the Coal Truth Office, 277 Smith St., Winnipeg, Man., for 75 cents.

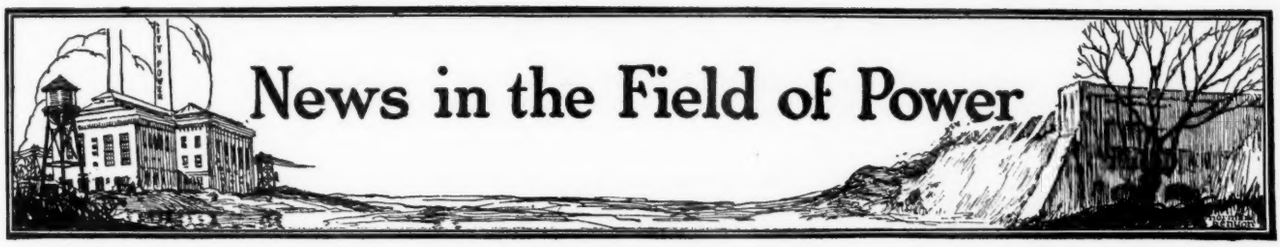
Investigation of Warm-Air Furnaces and Heating Systems, Part II, by A. C. Willard, A. P. Kratz and V. S. Day. Bulletin No. 141 Engineering Experiment Station, University of Illinois, Urbana. These investigations were conducted by the station in co-operation with the National Warm-Air Heating and Ventilating Association.

Weights and Measures, Miscellaneous Publications No. 35. Bureau of Standards. Sixteenth annual conference of representatives from various states held at the Bureau of Standards, Washington, D. C., May 21-24, 1923. Sold by the Superintendent of Documents, Government Printing Office, Washington, D. C. Price 30 cents.

Tests of Water Tube and Scotch Marine Boilers, by Henry Kreisinger, John Blizard, A. R. Mumford, B. J. Cross, W. R. Argyle and R. A. Sherman have recently been printed in Bulletin 214 by the Department of the Interior, Bureau of Mines. Can be had by writing for this bulletin.

Elementary Aëronautical Science, by Ivor B. Hart and W. Laidler. Published at the Clarendon Press, Oxford, England. Price, $2.75.

Swedish Year-Book, 1924. Published by Almquist, Wiksells Boktryckeri-A-B. Stockholm, Sweden. Printed in English. Cloth; 5¼x7½ inches.



Activities of the U. S. Bureau of Mines

By H. W. Brooks*

THE name of this important scientific Bureau of the Government does not ordinarily convey to the mechanical engineer the breadth of service which it is rendering such fields as fuels and combustion engineering in its application to boiler furnaces, locomotives, steel and metallurgical furnaces, smelters, ceramic kilns, coke ovens and gas-making equipment.

It is the function of the Bureau's Fuels Section "to conduct investigations concerning the utilization of fuels with a view to increasing safety, efficiency and conserving resources through the prevention of waste." Thus, for example, all power-plant problems relating to the elimination of waste of fuel are pertinent fields for Bureau research. Government research enjoys two advantages over industrial research. It is absolutely disinterested and non-partisan, hence is universally considered authentic; and secondly, government research experts devoting their entire lives to research work have the necessary time available for calm, contemplative, reflective study and judgment, which is oftentimes difficult where research must be expedited under the spur of production.

Present research work now being conducted by the Fuel Section of particular interest to the plant engineer includes the following current problems:

Microscopic work on constitution geology and chemistry of coal.

Heat of distillation of coal.

Complete gasification of coal.

Fusibility of ash.

Spontaneous combustion of coal.

Gum-forming constituents in artificial gas.

Co-operative investigation to determine the service conditions applying within boiler furnaces to determine proper application of refractories.

Tests to determine the composition of gases arising from a fuel bed.

Tests to determine the pressure required to force air through various sizes of anthracite.

A study of mechanical coal sampling and rapid analysis.

Determination of proper relation between coal fired per square foot of grate surface to combustion volumes for most efficient fuel-burning practice.

Analyses of the coals of the country.

Notable past research work of the Fuels Section includes the following problems, on which Bureau bulletins have already been issued:

Flow of heat through furnace walls.

Producer-gas investigations and tests.

Heat transmission in steam boilers.

Steaming tests of coals.

Methods of sampling and purchase of coal under specifications.

Solution of smoke problems.

Co-operative fuel and boiler tests with other government departments such as Shipping Board, Army, Navy, Treasury Department and others.

Pulverized-fuel testing.

Studies of hand- and stoker-fired boilers and methods of saving coal and their use.

Studies of lignites and peats as fuels.

Research in proper design constants of both power and domestic boilers, their testing and most economical utilization.

Tests and research on oil-burning internal-combustion engines.

Development of fundamental combustion information on fuel oils and most effective burning of them.

Utilization of petroleum and natural gas.

In the Experiment Station at Pittsburgh there is one of the most, if not the most, complete coal analytical laboratories in the United States, where an average of 600 to 1,000 analyses of coals are conducted each month. In this laboratory all coal tests for all government departments are conducted as well as the analyses incident to the research of the Bureau throughout the country. A great deal of notable work on petroleum engineering and the utilization of oil fuels has been done at the Bartlesville (Okla.) and San Francisco stations, as well as by the experts of the Petroleum Division at Washington. Additional laboratories of the Bureau having to do with the efficient production and utilization of mined products are situated at strategic points throughout the country.

Recognizing the advantages accruing to their industry, the American Society of Heating and Ventilating Engineers have, for the last five years, been guests of the Bureau of Mines Experiment Station at Pittsburgh, and maintained a co-operative research laboratory where fundamental information of importance to their industry has been studied. Problems of interest to the industry within the scope of the Bureau's work might include the following:

Efficiency of burning various pulverized fuels; for example, lignites, low-temperature coke and mixtures of cokes with coal, anthracites, etc. Design of combustion space, special refractory materials, water screens, water-cooled walls, and handling of ash. Cost of installation, upkeep, comparison with similar plants using stokers, operating efficiencies, etc.

Furnace conditions governing application of refractories.

Low-temperature carbonization of coal.

Complete gasification of coal.

Heat transfer and heat distribution in boilers, superheaters, air preheaters, evaporators, feed-water heaters and condensers.

Study of combustion of coal on various types of stokers and furnaces.

Study of mechanism of clinker formation.

Effect of scale and slag formation on heat transfer, and mechanism of scale formation in boilers, superheaters, economizers, feed-water heaters, etc.

Caustic embrittlement of steam boiler plates.

*Fuel Engineer, United States Bureau of Mines.

Part of the American delegation to the World Power Conference, following a luncheon aboard the "Scythia"

Power Shortage in Southern California

Drought Forces Twenty-five per Cent Curtailment in Demand—Power Administrator May Be Appointed

CONFRONTED with a dry year and an unprecedented increase in load, the Southern California Edison Co. has found it necessary to order a 25 per cent curtailment of power usage over its entire system. This order comes as a result of a conference between executives and engineers of all southern California electric utilities and representatives of the State Railroad Commission held in Los Angeles, June 13. The meeting was called at the instigation of the railroad commission to consider steps to meet the present emergency. Testimony at the hearing brought out that there would be a shortage of 126,000,000 kilowatt-hours on the Edison system during the last six months of the year which would require a curtailment of approximately 20 per cent. Other utilities represented at the hearing showed that they would be able to meet the demands for power on their own systems, and in the case of several of the companies they would be able to sell power to the Edison company to help relieve the situation.

A request was made by the utilities represented for the appointment of a power administrator to assist in an equitable distribution of the power available. The name of J. G. Butler, former chief of the division of water rights of the State Department of Public Works, who acted as power administrator during the shortage of 1920, has been suggested for the position.

Unnecessary employment of energy for flood lighting, display lighting, etc., will be discontinued first; industrial consumers, street railways and municipalities will be asked to reduce their energy consumption to three-quarter of normal; and the Los Angeles Bureau of Power and Light, the largest individual consumer on the Edison system, will receive a 25 per cent cut and will be forced to allocate this among its own customers. Other utilities of the section affected have not yet felt the necessity of ordering curtailment on their respective systems, but have agreed to carry on an educational campaign for conservation of power and to assist the Edison company by deliveries to it all surplus energy available.

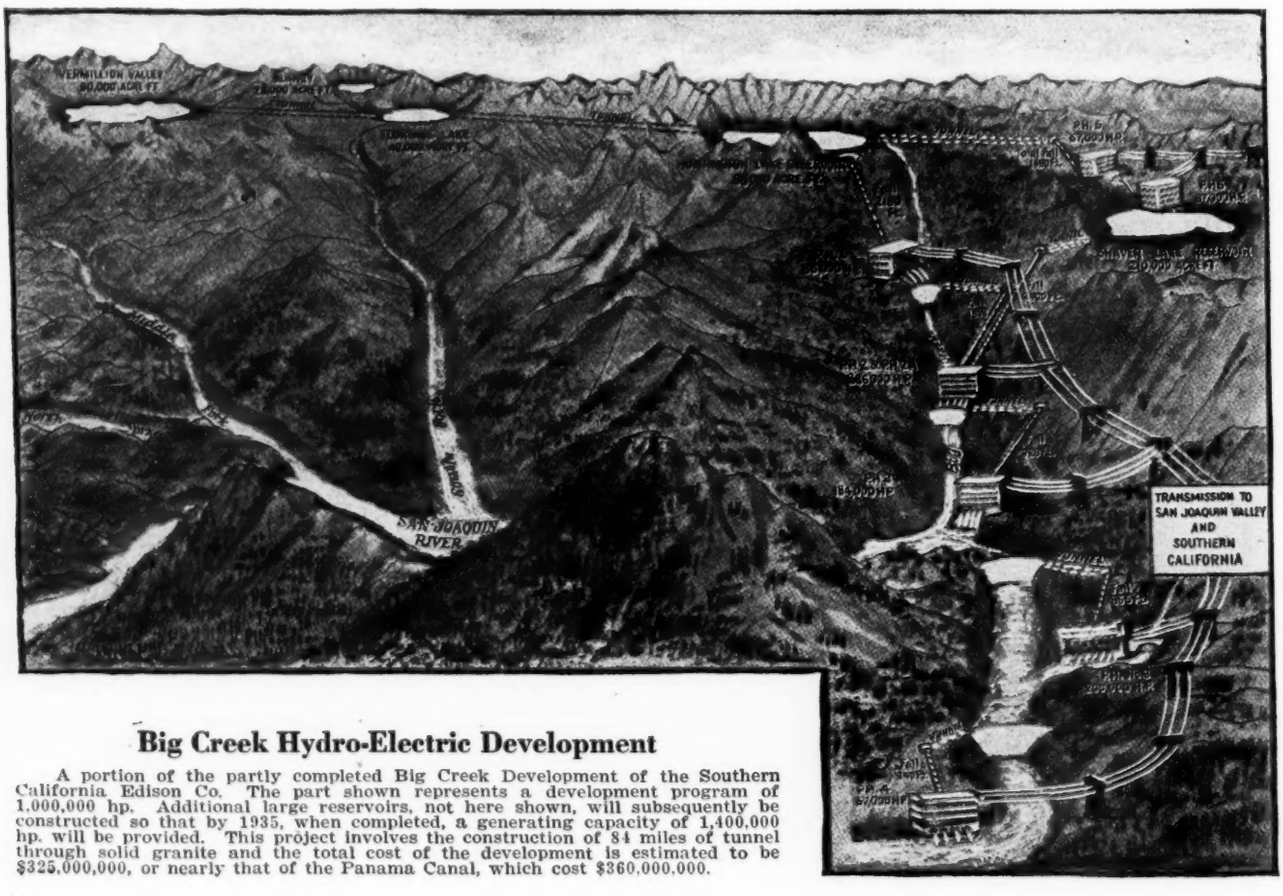
New equipment is being installed as rapidly as possible, and many obsolete steam plants are being rehabilitated and placed in service. Extensive use is being made of the large interconnected transmission system of the state for the interchange of power. Although the situation is acute in northern California, the utilities in that section expect to be able to meet the demands for power by rigid conservation without the necessity for enforced curtailment. No improvement in the situation is expected before the first of November or possibly later, unless early fall rains replenish the water supply.

Government Loses Specialists to Industry

Thirty specialists can resign in one year from one government bureau to go into industry at three times their federal pay envelope, and Congress doesn't sit up. But when one of them who was getting $2,400 from Uncle Sam as an oil expert, draws down $155,000 the first year from the company he signs up with, Senators and Representatives begin to take notice. The average government pay of the other twenty-nine was $2,241 a year, and their average industrial income the first year is estimated at $7,944. Both these incidents were reported by the Geological Survey.

The Patent Office reports nine technicians lost to them in April, and in the last six months of 1923 the Bureau of Mines lost six men out of fifteen in their Pittsburgh field division increasing their income 60 per cent. Three commissioners have resigned their $5,000 executive positions and are reported to be earning from $9,000 to $11,000 respectively in their business connections.

These resignations were brought to light as the result of a question raised during the hearing on the Hooker-White-Atterbury Muscle Shoals bid before the Senate Committee on Agriculture, where the point was raised that the government, as the operator of Muscle Shoals, would find it difficult to obtain and hold services of high-grade executives, engineers and other technical specialists, even at the maximum salary of $12,000 specified in the Norris



Big Creek Hydro-Electric Development

A portion of the partly completed Big Creek Development of the Southern California Edison Co. The part shown represents a development program of 1,000,000 hp. Additional large reservoirs, not here shown, will subsequently be constructed so that by 1935, when completed, a generating capacity of 1,400,000 hp. will be provided. This project involves the construction of 84 miles of tunnel through solid granite and the total cost of the development is estimated to be $325,000,000, or nearly that of the Panama Canal, which cost $360,000,000.

bill for the operation of Muscle Shoals under government ownership and control. The discussion initiated an investigation of the relative pay of government bureau technical employees in comparison with industrial remuneration for similar work and the results of the survey make significant reading.

The Geological Survey, however, has suffered the most, and its experts have been called to fill a wider variety of technical positions than those of any other department. Besides the thirty men who resigned during the year, two geologists have become members of the faculty respectively of Harvard and Yale at $6,000 as compared with $4,000 and $3,500 salaries the government paid them. An assistant geologist at $2,160 is now a consultant for a mining company at $20,000 a year, and two others who received $4,000 for government field work are paid $16,000 and $18,000 respectively for giving expert advice to development companies in the South and West.

Attacks Right of Eminent Domain

A sensational attack on the constitutionality of the eminent domain provisions of the Robinson state water power law was made by John P. Morrissey, Assistant Corporation Counsel of New York City, appearing in behalf of Mayor Hylan, at the final hearing before the Public Service Commission in the matter of the application of the Niagara, Lockport & Ontario Power Co. for permission to exercise the right of eminent domain over property in the town of Orwell, Oswego County, owned by the Horton brothers. Mr. Morrissey took the ground that the water-power resources of the state belong to the people and that the matter should be allowed to rest until the state undertook a policy of development of power resources for the public good.

The decision of the commission, which will be made shortly after the filing of briefs, will be viewed with interest not alone in New York State but throughout the nation. The provision of law that is attacked is the eminent-domain provision of the Robinson law, which was copied into the New York State statute verbatim from the Federal Esch law.

The controversy at issue is the first attempt for a private corporation owning 51 per cent of the developed and undeveloped power to a watershed attempting to obtain physical possession and control of the entire power possible to be developed.

John R. Freeman Offers Research Funds

In addition to the $25,000 endowment given the American Society of Civil Engineers for research, particularly in the field of hydraulics, John R. Freeman, past-president of the society, has offered like sums each to the American Society of Mechanical Engineers and the Boston Society of Civil Engineers. The gifts are made, Mr. Freeman explains, "because of a lively and grateful remembrance of the encouragement" which association with members of all three societies inspired. Mr. Freeman had provided in his will the making available of these trust funds, but before leaving for Europe recently he decided to make the money immediately available.

Mr. Freeman has suggested that aside from scientific research, the fund might be used for making translations of important engineering documents or in the publication of professional papers and memoirs that for lack of funds might go unpublished.

Narragansett Plant To Install Powdered Coal

Information has just been received that the plant of the Narragansett Electric Lighting Co. has contracted with the Combustion Engineering Corp. for the installation of pulverized-coal equipment under four new B. & W. boilers, aggregating 71,000 sq.ft. of heating surface. This will increase the boiler capacity of the South Street station about 50 per cent.

It will be recalled that the present boilers in this plant have been operating with fuel oil exclusively for several years, with the exception of a trial installation of pulverized fuel under one boiler which has been in use during the last year.

Power from Proposed Canal

State Engineer and Surveyor Dwight B. La Du is preparing estimates to show the cost of an American canal to connect Lake Erie with Lake Ontario, Such a canal would leave Lake Erie at Buffalo and follow a semicircular route to the Niagara River below the falls at Lewiston. This route would not only afford navigation facilities, but would permit of extensive state-owned power development, it is pointed out by Mr. La Du.

Any such diversion of water from the Niagara River would be subject to the same limitations as now defined by international treaty in relation to further development of Niagara power.

To Advise Shipping Board on Diesels

The advisory committee which will co-operate with the Shipping Board in a study of the situation surrounding the domestic Diesel Industry, comprises the following: Admiral H. I. Cone, chairman; A. Conti, consulting engineer, Shipping Board; C. A. McAllister, American Bureau of Shipping; Rear Admiral S. N. Robinson, Bureau of Engineering, U. S. Navy; Major W. D. Styer, Corps of Engineers; J. F. Nichols, Chief Engineer, Newport News Shipbuilding & Drydock Co.; William F. Gibbs, president, Gibbs Brothers, Inc.

Output of Fuel Oils and Lubricants

The output of gas and fuel oils for April, was 1,116,763,663 gal., an increase of 2,351,938 gal. over the March production. Stocks increased 45,683,595 gal. during the month.

The production of lubricants decreased during April 4,160,300 gal. from the March output.

Power Activities in Northern New York

Approximately three-quarters of the expansion, extension and improvement program authorized by the Adirondack Power & Light Co. about a year ago is now completed. An addition to the steam plant at Amsterdam is under way, which, when completed, will double its generating capacity from 30,000 to 60,000 kilowatts. A connection from Beardley Falls on East Canada Creek southward is being made to enable the Adirondack company to render service to the New York State Gas & Electric Co. and affiliated companies, while a westward connection through Oneida and Canastota will connect with the Niagara, Lockport & Ontario Power Co., allowing an interchange of current between the two corporations.

The Adirondack Power & Light Corp. has purchased the hydro-electric property at Hadley on the Hudson river in Saratoga County, and is making a number of miscellaneous internal improvements and alterations including the changing over of the balance of their system from a 40- to a 60-cycle.

The Power Corporation of New York, under a holding company plan, has taken over the Northern New York Utilities, Inc., of Watertown, the transaction representing a transfer of power interests valued at approximately $32,000,000 and controlling the output of approximately 100,000 hp.

The Watertown corporation now owns six developed power sites on the Black and Raquette Rivers, as well as certain undeveloped power. No application has been made to the public service commission for permission for the transfer of property. Whether the powers of the Power Corporation of New York are sufficiently broad to authorize such action without permission of the public service commission cannot be definitely stated, but the permission of that body is usually required for transfers of this kind.

Washington State Power Resources Surveyed

A contribution to the study of the hydro-electric resources of the State of Washington has just been made by Dr. Carl E. Magnusson, dean of the university school of electrical engineering. Coupled with the fruits of his survey, Dr. Magnusson recommends the establishment of a permanent state water-power commission to formulate plans for "the economic development of all the available power resources of the state," as a unified and interwoven superpower system.

Dr. Magnusson places Washington's available maximum hydro-electric development at 8,647,000 hp., or 16.04 per cent of the total maximum for the entire United States. This estimate, he says, is conservative and may be increased by 50 per cent in actual practice. Present power development in Washington amounts to but 5.02 per cent of the available maximum.

The Magnusson survey enumerates 88 "more desirable power sites, capable of developing from 10,000 to 750,000 hp. each. Development should keep

pace only with requirements, but the report directs attention to the advisability of early interconnection of separated power plants to effect economy of operation.

If auxiliary steam power is necessary in the earlier stages of hydro-electric development, Dean Magnusson believes it might better be furnished by one great steam plant located at or near a coal mine, instead of by scattered local plants.

Dr. Magnusson makes no specific recommendation for or against public ownership.

Water-Power Projects

Red Cedar and Chippewa Rivers.—The main undeveloped powers of the Wisconsin-Minnesota Light & Power Co., operated as a division of the Northern States Power system, are three on the Red Cedar River and seven on the Chippewa River.

Czechoslovakia—Czechoslovakia in its efforts to conserve coal and to reduce costs of manufacturing is turning to its water power. In furtherance of this purpose a dam is being built across the Valley of Cerna Desna, in Northern Moravia. The building of this dam will cost approximately 7,500,000 crowns, of which 40 per cent will be supplied by the government. Other water-power developments are being planned by the government to be carried out during 1924.

Recent Projects Licensed—Licenses have been authorized by the Federal Power Commission to cover the following projects: State of Illinois and Fred D. Breit, Fox River near Dayton, Ill.; Escondido Mutual Water Co., San Luis Rey River, San Diego County, Calif.; The Sitka Wharf and Power Co., Medvetcha Creek near Sitka, Alaska; Excelsior Water & Power Co., Yuba River, Nevada County, Calif.; A. E. Humphries, Goose Creek, Mineral County, Colo.

New Zealand Developing Hydro-Electric Plants—In accordance with a contract entered into with the Auckland Power Board, specifications have been drawn up and issued for the construction of a dam and head works at the Arapuni Rapids, Waikato River. The estimate calls for three generating units amounting to 45,000 kw., in 1928, together with additional units of 15,000 kw. each as required, also public transmission lines to Auckland, according to government reports.

Hydro-Electric Plant for Italy—Approval has been given by the Italian Supreme Council of Public Works of a concession to utilize the waters of the upper Adige in the Trentino for electrical power. A company has been organized by the Cities of Merano and Bolzano to construct a large hydro-electric plant, and it is reported that work will be begun immediately. Existing plants in the district are already owned by these municipalities, according to *Commerce Reports*.

Personal Mention

Gerard Swope, President of the General Electric Company was recently awarded the degree of Doctor of Science by Union College.

W. L. R. Emmet, of the General Electric Company, in recognition of his research and success in the mercury-vapor turbine and boiler, received a Doctor of Science degree from Trinity College.

Coming Conventions

American Electrochemical Society. Dr. Colvin G. Fink, Columbia University, New York City. General meeting at Detroit, Mich., Sept. 25-27.

American Institute of Chemical Engineers. Dr. John C. Olsen, Polytechnic Institute of Brooklyn, New York. Summer meeting in Denver, July 16-19.

Association of Iron & Steel Electrical Engineers, John F. Kelly, 1007 Empire Bldg., Pittsburgh, Pa. Annual meeting and exposition at Duquesne Garden, Pittsburgh, Pa., Sept. 15-20.

Management Congress, First International. Prague, Czechoslovak, July 21-24.

National Association of Stationary Engineers. Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual convention and exhibition at Hotel Pantlind, Grand Rapids, Mich., Sept. 8-13. Annual conventions and exhibitions of the state associations are scheduled as follows: **New England States Association** at Cambridge, Mass., July 10-12. Freeman L. Tyler, 32 Briggs St., Taunton, Mass. **Wisconsin Association** at Fond du Lac, July 24-26. Vincent Todd, 25 Fourteenth St., Fond du Lac. **Minnesota Association** at Faribault, Minn., July 31, Aug. 1-2. C. A. Nelson, 800 22nd Ave., N. E. Minneapolis. **Michigan Association** at Grand Rapids, Sept. 8. Wm. H. Yeomans, 209 Plainfield Ave., Grand Rapids. **Pennsylvania State Association** at Grand Rapids, Mich., Sept. 8. J. N. Calvert, Union & Ridenour Ave., Crafton, Pittsburgh, Pa.

New England Water-Works Association, Frank T. Gifford, 715 Tremont Temple, Boston, Mass. Annual convention at Powers Hotel, Buffalo, N. Y., Sept. 23-26.

Ohio Electric Light Association. D. L. Gaskill, Greenville, Ohio. Annual meeting at Hotel Breakers, Cedar Point, Ohio, July 8-11.

World Power Conference. O. C. Merrill, Federal Power Commission, Washington, D. C. British Empire Exhibition, Wembley, London, June 30-July 12.

Roger B. Stevens, formerly of McClellen & Junkersfeld, Inc., Engineers & Constructors, has become associated with Stevens-Aylsworth Co., Inc., contracting engineers, of New York City, in the capacity of manager of their engineering and sales departments.

Webster Tallmadge, Engineering Specialist, announces the removal of his offices from 50 Church St. to the new Westinghouse Bldg., 150 Broadway, New York City, where he will conduct business in engineering of steam power installations and high-efficiency heating systems.

Business Notes

The Economy Fuse & Manufacturing Co., Chicago, Ill., announces the appointment of Morgan P. Ellis as general sales manager.

The General Electric Co., Schenectady, N. Y., announces the opening of a new service shop in Kansas City, where the company's product will be repaired. Other repair sections will be located at the factories at Schenectady, Lynn, Erie, Oakland (Calif.) and Fort Wayne.

The Ramsey Chain Co., Inc., Albany, N. Y., manufacturer of chain drives, has just announced the appointment of the Morse Engineering Co., 549 West Washington St., Chicago, Ill., as its representative for the Chicago district. P. A. Morse is the active head of the new connection.

The General Electric Co., Schenectady, N. Y., announces some changes in personnel in its sales offices: K. A. Hills, since January attached to the Davenport office, has been made manager of that office, which covers a large part of Iowa in its territory; S. E. Gates, for 14 years in charge of the Spokane office, has been appointed manager of the Los Angeles office; Bernhard Olsen has been appointed manager of the Spokane office, succeeding Mr. Gates.

The Chicago Pneumatic Tool Co., in connection with its subsidiary companies, Canadian Pneumatic Tool Co., Ltd., Montreal, and the Consolidated Pneumatic Tool Co., Ltd., London, England, announces the transfer of Howard Bird, for several years general manager of the Canadian company with headquarters in Montreal, to the position of managing director of the Consolidated Pneumatic Tool Co., and director of European sales of the Chicago Pneumatic Tool Co., with headquarters in London, to succeed the late H. D. Megary; and the transfer of D. M. Wesbrook from district sales manager, Minneapolis branch, to Montreal, as general manager of the Canadian Pneumatic Tool Co. to succeed Mr. Bird.

S. F. Bowser & Co., Fort Wayne, Ind., announces organization changes: Donald K. Kingsley, formerly assistant manager of the Dallas office at 1815 Market St., Dallas, Texas, has been made manager of the Detroit office; Paul W. Lawther, of the Fort Wayne office has been made manager of the new Memphis office, 606 Salls Bldg., Memphis, Tenn.; E. E. Springer, formerly of the Atlanta office at 1510 Candler Bldg., Atlanta, Ga., has been made manager of the new Birmingham, Ala., office; H. C. Carpenter, of the Atlanta office, has been made manager of that territory; E. B. French, formerly manager of the Atlanta office, has been made sales superintendent at the Washington, D. C., office; R. S. Caldwell, recently at Fort Wayne as assistant sales manager has been made manager of the enlarged Philadelphia division located at the Abbott Bldg., Broad and Race Sts., Phila., Pa.

Trade Catalogs

Piping—Steere Engineering Co. Leaflet "Vacuum Piping Must be Tight," covers this welded steel vacuum tubing.

Filters, Air—Midwest Air Filters, Inc., Grand Central Terminal Bldg., New York City. Catalog F 302, "Air Filters for Compressors and Internal Combustion Engines," covers information concerning this filtration equipment. Tables and useful data are included.

Ventilators — The Swartwout Co., 18511 Euclid Ave., Cleveland, Ohio. "The Gospel of Fresh Air" is the title of an attractive catalog on ventilators and ventilations issued by this company. Many illustrations of installations give an idea of the diversified use of this equipment.

Pumps — Morris Machine Works, Baldwinsville, N. Y. Bulletin No. 122 covers the double centrifugal suction pump with horizontally split casing. Illustrations of the equipment and installation are shown. Tables of dimensions and curves of performances are given, and operating details explained.

Power Apparatus, Electric—Electric Machinery Manufacturing Co., Minneapolis, Minn. Bulletin No. 833 describes E-M junior synchronous motors for direct connection to small compressors. Bulletin No. 785 lists the firms using this equipment as well as the uses for which it is employed.

Refrigerating Supplies—Jos. A. Martocello & Co., Philadelphia, Pa., Catalog No. 50 illustrates and describes the Martocello Raw Water Ice Making Systems and Supplies. The material contained therein is original, having been obtained from actual research work, tests and performances. This catalog is recommended to refrigerating engineers who wish to be informed on the subject of raw-water ice making, and the company will furnish copies of the catalog to those interested.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	June 16, 1924	June 23, 1924
Pool 1	New York	$2.90	$2.90
Smokeless	Columbus	2.45	2.35
Clearfield	Boston	2.35	2.40
Somerset	Boston	2 50	2.50
Kanawha	Columbus		
Hocking	Columbus	1.85	1.85
Pittsburgh No. 8	Cleveland	1.90	1.90
Franklin, Ill.	Chicago	2.50	2.50
Central, Ill.	Chicago	2.25	2.25
Ind. 4th Vein	Chicago	2.50	2.50
West Ky.	Louisville	1.65	1.75
S. E. Ky.	Louisville	1.75	1.75
Big Seam	Birmingham	2.00	2.10

FUEL OIL

New York—June 26, light oil, tank-car lots, 28@34 deg. Baumé, 5¼c. per gal., 36@40 deg. 6c. per gal., f.o.b. Bayonne, N. J.

St. Louis — June 10, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.55 per bbl.; 26@28 deg., $1.60 per bbl.; 28@30 deg., $1.65 per bbl.; 32@36 deg., gas oil, 4½c. per gal.; 38@40 deg. 5c. per gal.

Pittsburgh—June 17, f.o.b. local refinery, 30@34 deg., fuel oil, 5¼c. per gal.; 36@40 deg., fuel oil, 5½c. per gal.; 34 deg., neutral, 8½c. per gal.

Dallas—June 20, f.o.b. local refinery. 26@30 deg., $1.30@$1.35 per bbl.

Philadelphia—June 19, 28@30 deg., $2.10@$2.163 per bbl.; 18@22 deg., $2.10@$2.16½; 13@16 deg., $1.78½@$1.848 per bbl.

Boston—June 20, tank-car lots, f.o.b. heavy oil, 12@14 deg. Baumé, 4¾c. per gal., light oil, 28@32 deg., Baumé, 6¾c. per gal.

Cincinnati—June 23, tank-car lots, f.o.b. local refinery, 24@26 deg., Baumé, 4¾c. per gal.; 26@30 deg., 5¼c. per gal.; 30@32 deg., 5⅝c. per gal.

New Plant Construction

Ala., Birmingham—The Continental Gin Co., Title Guarantee Bldg., Dallas, Tex., is reported to be planning construction of a boiler plant at its proposed new manufacturing works at Avondale, near Birmingham. L. R. Munger is president.

Ala., Birmingham—The Alabama Power Co., has tentative plans for a series of hydroelectric plants on the Tallapoosa River, to develop a total of 90,000 hp. The project will be carried out over a period of months, involving more than $15,000,000.

Ariz., Flagstaff — The Flagstaff Steam Laundry plans for the installation of a boiler plant at its new laundry, for which plans are being drawn by A. Godfrey Bailey, Hill St. Bldg., Los Angeles, Calif., architect.

Ariz., Yuma—The Hartley Brothers Ice & Cold Storage Co., plans extensions, including a 20-ton ice-making machine, and auxiliary equipment, estimated to cost $50,000. Seth Hartley is general manager.

Brazil, Bahia — United States Consul Homer Brett, Bahia, has information regarding a company at Jequie, State of Bahia, which has secured water rights and plans for the construction of a hydroelectric power plant, for which equipment is expected to be purchased during the present year. The Bureau of Foreign and Domestic Commerce, Washington, D. C., has data, also, regarding the project under Reference No. 132700.

Calif., Madera—The San Joaquin River Water Storage District has engaged A. J. Wiley, Boise City, Idaho, consulting engineer, to prepare plans for its proposed power dam and hydroelectric power station.

Calif., Manteca—The Board of Directors, South San Joaquin Irrigation District, has authorized the sale of $430,000 in bonds, the proceeds to be used in part for a number of electric-operated pumping plants.

Cal., Livingston — The Board of City Trustees contemplates the installation of centrifugal pumping equipment at its proposed municipal waterworks. The plant will cost $57,000. A. E. Cowell, Merced, Calif., is consulting engineer.

Calif., Tracy—The Board of Directors, Banta-Barbona Irrigation District, plans for a bond issue of $705,000, for the installation of an irrigation works, to include pumping plants.

Calif., San Francisco—Bids will soon be asked by the constructing quartermaster, Fort Mason, for two centrifugal pumps, one 1,000 g.p.m. single stage; and one 1,500 g.p.m., single stage.

Calif., Eureka—The Humboldt Lumber & Building Co., 233 G St., contemplates the installation of a boiler plant at its local lumber and woodworking mill. It will cost close to 100,000. D. H. McFarlan is general manager.

Calif., Coronado—The Coronado Water Co., is planning a series of electrically operated pumping plants for underground water supply from the Tijuana River valley. The entire project will cost $125,000.

Calif., Los Angeles—The Hammond Lumber Co., 2010 South Alameda St., is having plans prepared for an addition to its boiler plant.

Calif., Elsinore—The Board of Trustees, Ladera Irrigation District, plans for two or more pumping plants in connection with an irrigation project. A bond issue will be arranged. Olmsted & Gilfelen, Hollingsworth Bldg., Los Angeles, are consulting engineers. A. L. Adams, Elsinore, is secretary.

Calif., Visalia—The Acme Ice Cream Co., plans for a refrigerating plant at its new factory in the Hyde Tract. Roy Greenfield is general manager.

Calif., Oakland—The Schumacher Wall Board Co., 210 American Bank Bldg., San Francisco, plans a boiler house at its proposed local plant on site recently acquired.

Conn., New Britain—The State Board of Education, Hartford, has plans in preparation for the construction of a central steam power and heating plant at the local state normal school, estimated to cost $42,000. A coal pocket will be constructed. Alfred S. Kellogg, 89 Franklin St., Boston, Mass., is engineer.

D. C., Washington—The superintendent of State, War and Navy Buildings, 1034 Navy Bldg., will soon take bids, to be opened on date still to be decided, for power plant equipment for the various buildings, as per specifications on file.

D. C., Washington—The Bureau of Supplies and Accounts, Navy Department, will take bids until July 8, for a quantity of seamless boiler tubes for the Brooklyn, N. Y., and Mare Island, Calif., navy yards, as per Schedule 2360.

D. C., Washington—The general purchasing officer, Panama Canal, will take bids until July 21, for Diesel engine-driven generator equipment for stand-by generator stations, as specified in Circular 1617. Also, until July 9, for pump, water buckets and other equipment, as per Circular 1616.

Fla., Stuart—The Stuart Ice Co., has acquired site and plans an ice-manufacturing plant, for which a list of equipment will be arranged at an early date. F. E. Murphy is president and general manager.

Fla., Coconut Grove—The City Council has tentative plans maturing for its proposed municipal waterworks, to include a pumping station with centrifugal pumps, air compressors, etc. It is still to be determined whether motor or engine-driven units will be used. A water softening plant

is under consideration. George A. Main, 14 Baker St., Dayton, Fla., is consulting engineer.

Fla., Homestead—The City Council contemplates the installation of centrifugal pumping equipment in connection with a proposed waterworks and sewerage plant, estimated to cost $235,000, complete. A special election has been called on July 8, to vote bonds.

Fla., Tampa—The Interstate Investment Co., has plans nearing completion for its proposed waterfront terminal project, and will soon begin work. The work will include a cold storage and refrigerating plant. A fund of $3,000,000 will be used for the improvement. Lockwood, Greene & Co., Healey Bldg., Atlanta, Ga., are engineers.

Fla., Sarasota—The City Council is receiving bids until July 7, for the purchase of $215,000 city bonds, of which $125,000, will be used for extensions and betterments in the municipal electric plant, including additional equipment.

Ga., Cairo—The Cairo Ice & Cold Storage Co., plans rebuilding of the portion of its plant recently destroyed by fire, with loss reported at $18,000.

Ga., Savannah—The supervising architect, Treasury Department, Washington, D. C., will take bids until July 9, for an ice-making and refrigerating plant for installation at the local marine hospital.

Ga., Elberton—The Granite City Cannery, P. O. Box 762, T. N. Colley, president, plans a boiler plant in its canning factory, for which plans are nearing completion.

Idaho, Nampa — The City Council has authorized preliminary surveys for its proposed municipal electric power plant, and purposes to have detailed plans drawn in the near future.

Ind., Indianapolis—The Board of Works will make extensions and improvements in the boiler house at the Nurses Home. Adolph Scherrer, Indiana Trust Bldg., is architect.

Ind., Mooresville—The Board of School Trustees will take bids until July 11, for a central steam power plant for the local schools. W. H. Garns, Fletcher Trust Bldg., Indianapolis, Ind., is architect.

Ky., Louisville—The Kentucky Hydro-Electric Co., has disposed of a bond issue of $4,000,000, a portion of the proceeds to be used for extensions, including the completion of a hydro-electric power plant on the Dix River, now in course of building, designed for a capacity of 22,500 kw.

La., Shreveport—The Texas & Pacific Railroad Co., Dallas, Tex., plans a boiler plant at its proposed local shops and terminal at Jewella.

La., De Ridder—The City Council is having plans drawn for a municipal pumping plant for waterworks service, with capacity of 1½ m.g.p.d. Henry A. Mentz, Magnolia, Miss., is engineer.

La., Amita—The Central Light & Power Co., contemplates installing a 1,000 kw. turbo-generator and accessory equipment at its power plant.

Md., Cumberland—The Potomac Edison Co., is selling a bond issue of $1,000,000, the proceeeds to be used for expansion and financing.

Mich., Calumet—The Calumet & Hecla Consolidated Copper Co., contemplates the installation of electric hoisting equipment at one of its shafts, replacing present steam-driven apparatus.

Mich., Albion—The Michigan Artificial Ice Products Co., Real Estate Exchange Bldg., Detroit, has awarded a building contract to David Little, 702 Locust St., Kalamazoo, Mich., for an ice-manufacturing and cold storage plant at Lynn and Barnes Sts., estimated to cost $85,000. Milton Carmichael is secretary.

Minn., Owatonna—Bids will be received by the Utilities Commission until July 8, for a municipal light, power and central heating plant, including two 500 kw. turbo-generators; two 300 hp. boilers; stack, switchboard and auxiliary equipment. Arthur L. Mullergren, Gates Bldg., Kansas City, Mo., is engineer.

Miss., Vicksburg—M. L. Worrell, city manager and engineer, will receive bids until July 21, for a steam boiler and accessory apparatus for the waterworks.

Mo., Buffalo—The Common Council is reported to be planning the installation of centrifugal pumping equipment in connection with a proposed waterworks; a fund of $40,000 has been arranged for the project. Russell & Axon, Springfield, Mo., are engineers.

Mo., Portageville—The Common Council is considering the installation of centrifugal pumping equipment at its proposed waterworks, for which plans will be prepared by A. C. Moore, Joplin, Mo., engineer. Bonds for $40,000, are being arranged.

Mo., Waynesville—The Central Missouri Power & Water Co., has secured a preliminary permit from the Federal Power Commission for the construction of two hydro-electric generating plants on the Gasconade River to develop a maximum of 56,000 hp.

Mo., Washington—The City Council has authorized plans for a municipal waterworks, to include pumping machinery, steel water tank and tower, capacity 250,000 gals., and accessory equipment. W. B. Rollins & Co., Exchange Bldg., Kansas City, Mo., are engineers.

Neb., Omaha—The Nebraska Power Co., is disposing of a bond issue of $1,000,000, a portion of the proceeds to be used for extensions in power plants and system.

N. J., Atlantic City—A steam power plant will be installed in the fifteen-story hotel to be erected at the Boardwalk, Providence and Boston Aves., estimated to cost $3,750,000, for which plans are being completed by Maynicke & Frank, 25 East Twenty-sixth St., New York, architects.

N. Y., Troy—The Troy Coke & Iron Co., contemplates a steam power plant at its proposed gas-generating station for service at Schenectady, Albany and vicinity.

N. Y., Watertown—The Northern New York Utilities, Inc., has applied for permission to construct and operate hydro-electric power plants at Soft Maple on the Beaver River, and at Sewall's Island, Black River, estimated to cost in excess of $650,000.

N. Y., Binghamton — The Delaware, Lackawanna & Western Railroad Co., Hoboken, N. J., is reported to be planning a boiler plant at its proposed local shops.

N. Y., New York—The Quality Laundry Service, Inc., 251 Third Ave., plans a boiler plant at its proposed laundry at the Southern Blvd. and 134th St., estimated to cost $500,000, for which plans will soon be prepared.

N. Y., Brooklyn—The Brooklyn Union Gas Co., 176 Remsen St., has plans in preparation for a coal storage and distributing plant, and general service building at 54 Sixty-fifth St., estimated to cost $350,000, with coal-handling machinery and other mechanical equipment.

N. C., Wilmington—The Tidewater Power Co., is disposing of a bond issue of $1,070,500, a portion of the proceeds to be used for extensions in power plants and system.

N. C., Greensboro—The Parker Coal Co., recently organized, plans for the installation of coal-handling machinery at its proposed local distributing plant, including bins, portable unloader, conveying and hoisting machinery. J. A. Parker, 705 Walker Ave., is secretary and general manager.

N. C., Belhaven— C. R. Nickerson, Belhaven, is planning for the purchase of an electric-operated ice-making machine and accessories for installation in a local plant, about 15 tons capacity.

N. C., Forest City—The Trout-Wilkie Lumber Co., C. A. Wilkie, secretary, is considering the installation of a water turbine, generator and accessory equipment for local mill service.

N. D., Minot—The Great Northern Railway Co., St. Paul, Minn., is reported to be planning the construction of a boiler plant at its proposed local engine house. Also, for a similar boiler station installation at a new engine house at Williston, N. D.

Ohio, Canton—The J. H. Thompson Hotels Co., 420 Leader-News Bldg., Cleveland, O., plans a steam power and pumping station at its proposed local hotel. G. P. Post & Sons, Hanna Bldg., Cleveland, are architects.

Okla., Hobart—The Inland Utilities Co., has secured a franchise and plans a local power station, using an oil engine. J. E. Wright is engineer in charge.

Okla., Clinton—The Oklahoma Gas & Electric Co., has acquired the local municipal steam-operated power plant, and plans for enlargements for central-station service, including the installation of additional equipment.

Ore., Dallas—The Willamette Valley Lumber Co., is reported to be planning a boiler house in connection with the proposed rebuilding of its local mill, recently destroyed by fire with loss of about $150,000.

Pa., Philadelphia—The Industrial Cold Storage & Warehouse Co., American and Berks Sts., is arranging for a preferred stock issue of $100,000, the proceeds to be used for proposed extensions and financing.

S. D., Miller—The Common Council plans for extensions in the municipal power plant, including the installation of additional boiler equipment and other apparatus. G. C. Briggs is city clerk.

S. D., Sioux Falls—Bids will be received by the Board of Commissioners until July 7, for the construction of a municipal waterworks power station. Joseph Schwarz, Sioux Falls, is architect.

Tenn., Columbia—The Southern Cities Power Co., Chattanooga, has awarded a general contract to Foster & Creighton, Nashville, for the construction of a hydro-electric power plant, estimated to cost $110,000. Orders will be placed for equipment in the near future. Freeland, Roberts & Co., Nashville, are consulting engineers.

Tex., Miami—The Common Council plans for the rebuilding of the portion of the municipal electric power plant recently destroyed by fire, and will replace equipment.

Tex., Dallas—The Texas Power & Light Co., has issued bonds for $1,500,000, a portion of the proceeds to be used for extensions in power plants and system.

Tex., Navasota—S. D. Merrett, Navasota, and associates, plan for the installation of an oil engine and auxiliary equipment in connection with a proposed cotton ginning plant on local site, estimated to cost $30,000.

Tex., Brownwood — Under the direction of the local Chamber of Commerce, a hydro-electric power project is being developed, providing for the construction of a station at the Narrows, near the Pecan Bayou. An irrigation system will be installed to reclaim more than 25,000 acres of land. The entire project will cost in excess of $1,200,000.

Tex., Whitney — The Common Council contemplates the installation of centrifugal pumping equipment in connection with a proposed waterworks, for which preliminary plans are being prepared by the Municipal Engineering Co., Praetorian Bldg., Dallas, Tex., engineer.

Tex., Houston—The Board of Works has preliminary plans for a new central boiler and heating plant in the city auditorium, estimated to cost $90,000.

Va., Virginia Beach—The Common Council contemplates the installation of centrifugal pumping equipment in connection with waterworks system extensions. Bonds for $75,000 have been approved.

Wash., Seattle — The City Council is disposing of a bond issue of $1,500,000, the proceeds to be used for extensions in the municipal power plant and system.

Wash., Winlock—Frye & Co., Walker and Ninth St., South, Seattle, will begin foundations at once for a local cold storage plant on First St.

W. Va., Northfork—Swift & Co., Union Stock Yards, Chicago, Ill., plans a cold storage plant in connection with a two-story packing house on local site.

W. Va., Elmgrove—The Council is said to have preliminary plans under consideration for a new pumping plant at the waterworks, to be used primarily for booster service. J. S. Butts is city manager.

Wis., Hurley — A stock company has been formed to construct and operate a local waterworks plant and system. It is planned to install a pumping station, with centrifugal pumps and accessories. The project will cost $75,000. J. H. Emuson is city clerk.